Sediment and Benthic Community Assessment of the St. Marys River

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Sediment and Benthic Community Assessment of the St. Marys River

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DISCLAIMER

The initial drafts of this report were prepared for the Ontario Ministry of the Environment as part of a Ministry investigation of sediment quality and benthic community health in the St. Marys River.

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EXECUTIVE SUMMARY

Eight stations in the upper St. Marys River, spanning a distance of about 40 km., were sampled in 1992 by the Ontario Ministry of the Environment. Six of these stations were located in Canadian waters, ranging from the furthest upstream in Point aux Pins Bay (upstream of the St. Marys Falls), downstream to Little Lake George. The two stations in American waters were located in Tannery Bay, also upstream of the Falls, and in Lake George. This study was part of a continuing monitoring program of environmental quality in the St. Marys River. This report provides the benthic invertebrate community, sediment chemistry and toxicity results. A comparative integrated analysis was undertaken to summarize data, and to investigate relationships among stations and environmental parameters.

The major findings of this report are:

Sediments in the Algoma Slip were devoid of benthic invertebrates and were also acutely toxic in laboratory sediment bioassays. Elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) were found in these sediments and appear to be linked to the observed toxic impacts. Statistical (i.e., ordination and cluster) analysis of the benthic invertebrate data identified three groups among the seven remaining sampling stations. These were identified as: Group I (Tannery Bay); Group II (Lake George Channel and Lake George) and Group III (Points aux Pins Bay, Little Lake George, Bellevue Marine Park and Lake George Channel).

Contaminants found at elevated concentrations in the St Marys River sediment samples included arsenic, cyanide, heavy metals, solvent extractables (oils and greases) and PAHs. No polychlorinated biphenyls (PCBs), chlorinated phenols, chlorinated benzenes, organochlorine pesticides, phenoxyacid herbicides or triazine herbicides were found in river sediments above their respective analytical minimum reporting limits. Significant correlations were found among sediment chemistry parameters within specific contaminant groups for metals, PAHs and dioxins and furans. Principal components analysis was used to reduce the multivariate data sets to one or two principal components for these parameter groups and for sediment particle size data. A strong positive correlation was observed between total organic carbon (TOC) and PAH concentrations in the sediments.

Discriminant function analysis using principal components derived from environmental variables (as outlined above), discriminated among station groups derived from the benthic invertebrate community data. Based on this analysis, PAHs, TOC and station depth appeared to be important factors affecting benthic communities. Particle size, total phosphorus, total Kjeldahl nitrogen and calcium were also identified as environmental variables possibly influencing the benthic communities. However, this conclusion must be interpreted cautiously in light of the inherent limitations of the data. Spatial autocorrelation may be in part responsible for the observed relationships.

Laboratory sediment bioassays with *Hexagenia limbata* nymphs and *Chironomus tentans* larvae

indicated toxicity in all sediments except those from the two stations upstream of St. Marys Falls and Sault Ste. Marie point source discharges (i.e., Point aux Pins Bay and Tannery Bay). Bioassays using juvenile fathead minnows (*Pimephales promelas*) did not detect toxicity in any sediments. In general, the sediment toxicity results were in agreement with the benthic invertebrate community and chemistry results. There were however, several apparent exceptions, including:

- Concentrations of chromium exceeded the Provincial Aquatic Sediment Quality Severe Effect Level (SEL) guideline in Tannery Bay sediments, but no toxicity or negative effects on the benthic invertebrate community were apparent; and

- Sediments from stations in Bellevue Marine Park and Lake George Channel were more closely associated in terms of toxicity test results than was predicted by benthic invertebrate community or sediment chemistry information.

- Concentrations of copper, cadmium and fluorene exceeding Provincial Aquatic Sediment Quality Lowest Effect Level (LEL) guidelines in Point aux Pins Bay were apparently not toxic to benthic taxa, as indicated by the sediment bioassay results. Sediment toxicity would therefore not appear to be an important factor contributing to the relatively low richness and productivity of the benthic community at that station.

Good evidence exists to suggest that toxicity from contaminants in sediments is impacting benthic communities at Bellevue Marine Park and in Lake George Channel. At the former, where the highest degree of toxicity was observed, asellid isopods dominated the benthic community, which may indicate a low relative sensitivity of this taxon to the effect of pollutants. Based on comparisons of contaminant levels among sites, a specific contaminant and/or environmental conditions could not be identified which could be related to the high degree of toxicity observed for Bellevue Marine Park sediment.

Sublethal toxicity was observed in bioassays with the sediments from Little Lake George and Lake George, and these stations may be slightly impacted by such effects, either alone or in combination with organic enrichment. Most notably, the benthic community from Lake George was indicative of effects associated with organic enrichment.

Benthic communities at a station in Lake George Channel just downstream of the East End sewage treatment plant outfall exhibited characteristics of a classic organic enrichment model, resulting in very low diversity and high abundance of a few pollution-tolerant species.

Comparison of benthos and sediment quality data with 1983, 1985, 1987, 1989 and 1990 surveys showed that benthos status appears to have changed little over the years. Concentrations of a some sediment contaminants decreased over time; for others, the trend was variable, or perhaps increasing in recent years. A decreasing tend was more evident at the Little Lake George and Lake George than at further upstream stations, perhaps due to their more depositional nature.

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The study was proposed and designed by P.B. Kauss of the Ontario Ministry of the Environment's Environmental Monitoring and Reporting Branch. Sampling was conducted from the Ministry survey vessel *Monitor VI* (captained by Rick Savage), by crew chief Greg Hobson and summer student Jim Joukema. Sediment analyses were completed by staff of the Ministry's Laboratory Services Branch. Sediment bioassays were performed by the Ministry's Sediment Testing Laboratory.

Benthic sorting and taxonomy was completed at the Integrated Explorations Laboratory in Guelph, Ontario, under the direction of Al Melkic, with Wanda Cook as benthic invertebrate taxonomist. This analysis and report were completed under contract to the Ontario Ministry of the Environment, through funding provided by Fisheries and Oceans Canada. The efforts of Doug Geiling and of Dr. John Kelso (Fisheries and Oceans Canada, Sault Ste. Marie, Ontario) in arranging this support are greatly appreciated.

Review and comments on the initial draft report were provided by Rein Jaagumagi, Keith Somers and Peter Kauss. A copy of the draft report was also provide to the St. Marys River Remedial Action Plan in 1998 to assist in updating the status of the river.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CC	Coefficient of Community
H'	Shannon-Wiener Diversity index
LEL	Lowest Effect Level (see PSQG)
OMOEE	Ontario Ministry of Environment and Energy
OMOE	Ontario Ministry of the Environment
p	probability value
PAH(s)	polynuclear aromatic (or polyaromatic) hydrocarbon(s)
PCA	Principal Components Analysis
PSQG	Provincial Sediment Quality Guidelines
r	regression factor
SEL	Severe Effect Level (see PSQG)
TOC	total organic carbon

1.0 INTRODUCTION

In late August 1992, the Ontario Ministry of the Environment collected grab surface sediment samples as part of a continuing program of environmental monitoring of the St. Marys River (Kauss, 1992). Eight stations, distributed along a 40 km length of the upper river, were sampled for benthic invertebrate community analysis, chemical analysis and toxicity testing. The study area and sampling locations are illustrated in Figure 1.

The following report provides the results and interpretation of the 1992 survey data to assess sediment quality in the St. Marys River.

2.0 OBJECTIVES

The 1992 study was conducted to:

(i) update and enhance the Ministry's database on inorganic and organic contaminants in St. Marys River surficial sediments at selected locations;

(ii) determine if present concentrations of sediment-associated contaminants are above background and/or exceeding available criteria; and if so, determine if these levels correlate with impairment of the benthic invertebrate community or with toxicity to laboratory test organisms; and

(iii) identify inorganic and organic contaminants that are not routinely analyzed for but which may be exerting a toxic influence on the sediment-dwelling invertebrates, thereby delaying recovery of the benthic communities.

3.0 METHODS

3.1 Field Methods

The eight sampling locations extend from upstream of Sault Ste. Marie, to about 40 km downstream in Lake George are (Fig. 1). These stations were selected on the basis of past survey information (Burt *et al.*, 1991; Kauss & Hamdy, 1991; Pope & Kauss, 1995), to provide an update over a relatively large geographic area. Descriptions and coordinates are provided in Appendix A.

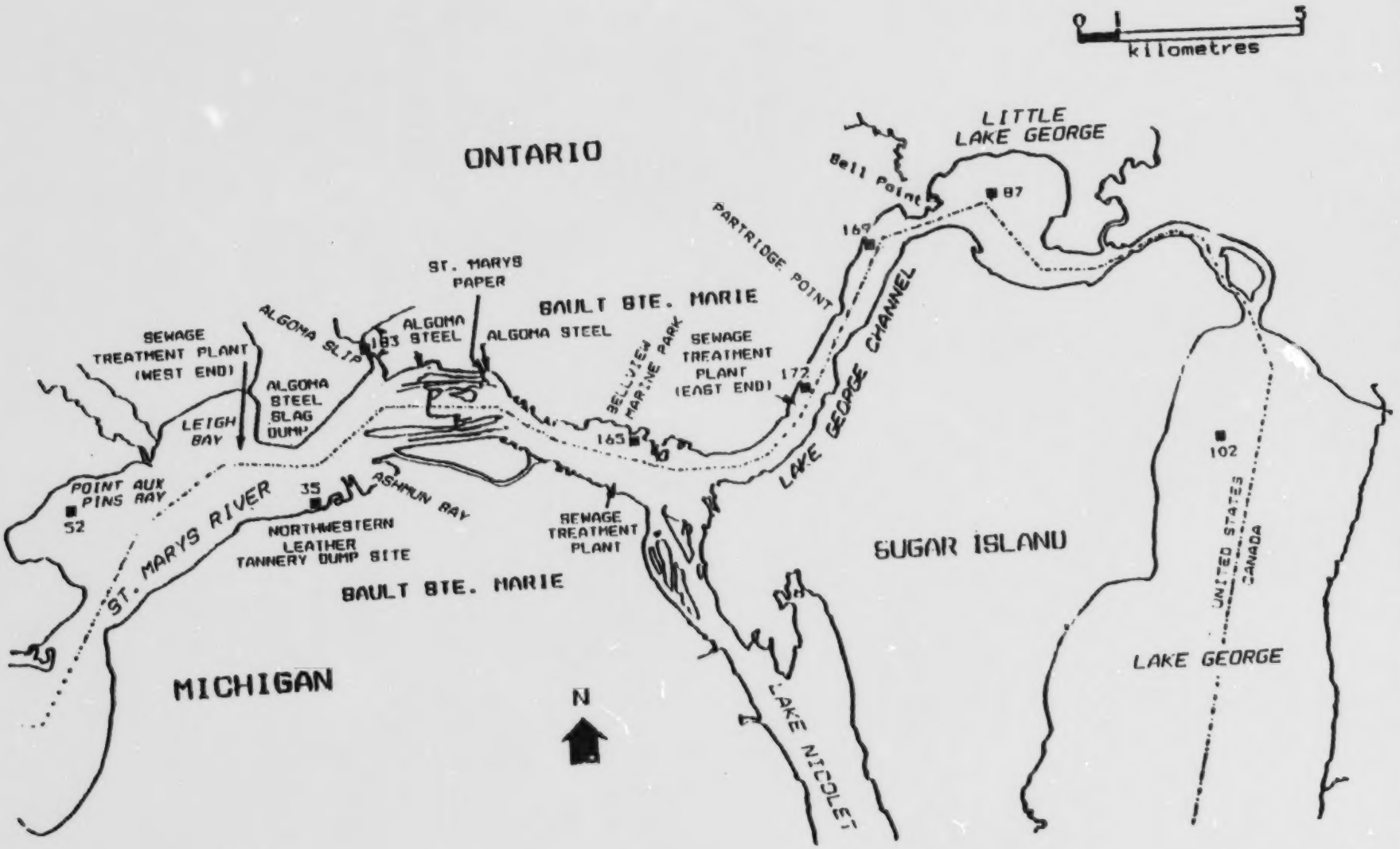

Figure 1. St. Marys River sediment sampling stations in 1992.

3.1.1 Field Measurements

Prior to sediment sampling at each station, pH was measured just above (~15 cm) the sediment surface using appropriate calibrated meter.

3.1.2 Sediment Collection

Three replicate samples of sediment were collected at each of the eight stations using a clean (rinsed with HPLC grade hexane) stainless steel Ponar dredge of 0.05 m^2 sampling area. For each of the three replicate samples required per station, the upper 10 cm of multiple grabs were removed and placed in a large, clean (hexane-rinsed) stainless steel pan. Once 6 litres had been obtained, the sediment was gently but thoroughly homogenized with a clean (hexane-rinsed) stainless steel spoon. Redox potential (Eh) and pH were then determined using appropriate calibrated meters.

3.1.3 Benthic Invertebrate Sample Preparation

One quarter by volume (1.5 litres) of the above sediment homogenate was placed in a 200 µm mesh Nitex bag and gently washed with river water. The retained meiobenthic material was then transferred to a large plastic screw-capped jar and the organisms immediately preserved with sufficient buffered (pH~7) formalin. Benthic invertebrate samples were stored at room temperature until sorting, identification and enumeration of the organisms could be carried out.

3.1.4 Sediment Chemistry Sample Preparation

A small volume of the above sediment homogenate had been weighed (using a glass jar of known volume) and the wet weight recorded to permit calculation of field density. Sediment was then distributed among the prescribed sample jars or containers, preserved as required (OMOE, 1989a) and shipped to the Ministry Laboratory Services Branch in Etobicoke for analysis.

3.1.5 Sediment Bioassay Sample Preparation

The remaining sediment homogenate (about 3 litres) from each station replicate was placed in a large, labeled food-grade polyethylene bag and, along with the other two replicates, put in a pre-cleaned plastic pail and shipped to the Ministry Sediment Bioassessment laboratory in Etobicoke.

3.2 Analytical Methods

3.2.1 Benthic Invertebrates

All meiobenthic invertebrates were sorted from the sediment and debris of each sample. The sediment remaining after sorting was checked for missed invertebrates using a 10X power stereo microscope. This material was then preserved in the original sample jar and archived.

Subsampling

Taxa occurring in numbers exceeding 100 individuals per sample were subsampled, such that a minimum of 200 specimens were collected. All samples were split into equal fractions of 1/8 or 1/16 in a flat sorting pan. As sorting proceeded, specimens were separated into general classes for subsequent identification. During this process, the number of individuals within each class were recorded to provide an inventory and to compare the class distribution in subsequent subsamples. Usually, three to five subsamples were sorted and analyzed to provide some measure of sub-sampling consistency within a sample. For each subsample, the left over material was checked to assure that no more than 10 % of the invertebrates had been overlooked. The remaining sample fraction (i.e., the entire sample) was subsequently sorted for those taxa occurring at numbers less than 100 per sample. A detailed catalogue of sorted specimen vials was maintained indicating the sample identification and the total fraction sorted for each class vial in order to calculate total numbers per sample.

Invertebrate Identification

All benthic invertebrates, including all insects, crustaceans, molluscs, annelids, and round worms were identified to the generic level. Late-instar/mature leeches, worms, stoneflies, *Stenonema* and *Hexagenia* mayflies, dragonflies, *Gammarus* amphipods, adult beetles and bugs were identified to the species level. Chironomids were identified to the genus, and where practical and significant to the species level. Lepidopterans, ceratopogonids, empidids, muscids and flatworms were identified to the family level only. Nemerteans and nematodes were only identified to phylum. All invertebrates were identified according to the taxonomic keys listed in Section 6.

Quality Assurance

During sorting, a log was kept for each sample, indicating the subsample fraction, the sorting technician, the numbers of individuals per class and picking efficiency. Sorting efficiency and accuracy was determined on 10% of all samples by an experienced sorter other than the original technician. Subsampling precision was determined on 10% of all samples. A comparison of the invertebrates sorted between subsamples of the same sample was performed to identify any significant differences among subsamples. Where anomalies in benthic invertebrate distributions among subsamples were identified, the entire sample was sorted.

Standard taxonomic keys were used; these have been listed in this report to provide continuity

with respect to ongoing name changes. A reference collection was prepared containing representatives of each taxon identified. The specimens of the reference collection were preserved in 80% ethanol in shell vials with a Teflon® stopper, and slide mounts with Canada Balsam or CMCP. All vials and slides are labeled with the pertinent information (location, taxon and date) and are catalogued.

3.2.2 Sediment Chemistry

Sediment samples were submitted to the Ministry Laboratory Services Branch in Etobicoke and analyzed according to documented procedures (OMOE 1989b; OMOE,1990, OMOEE,1994a-c; OMOEE 1995a-f; OMOEE, 1996; OMOEE, 1997a-c). Laboratory analysis of the 24 samples (i.e., eight stations, each with three spatial replicates) included:

(i) Metals, Nutrients, etc.
Particle Size Distribution scan
Percent Moisture
Loss on Ignition
Total Organic Carbon
Nutrients (Ammonia, Kjeldahl Nitrogen, Phosphorus)
Major Ions (Calcium, Chloride, Magnesium)
Arsenic
Cyanide, available
Metals (Aluminum, Barium, Cadmium, Cobalt, Chromium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Selenium, Silver, Vanadium, Zinc)

(ii) Organics
Solvent Extractables (Oils & Greases)
Infrared Spectroscopy of unknowns
Polycyclic Aromatic Hydrocarbons scan (16 compounds)
Chlorinated Industrial Organics scan (14 compounds)
Organochlorine Pesticides and total PCBs scan (21 compounds)

(iii) Other Organics
Phenoxy Acid Herbicides scan (7 compounds)
Speciated Phenols scan (18 compounds)
Triazine Herbicides scan (8 compounds)
Polychlorinated Dioxins and Furans scan (10 homolog groups & 17 isomers)
Extractable Organics by full scan Gas Chromatography/Mass Spectrometry

Replicate sediment samples were initially submitted only for analysis of parameter groups (i) and (ii). Duplicate sediment samples were kept frozen at -15°C until they could be analyzed for the

secondary organic scans listed above in group (iii). Due to sample load and cost limitations, only one of the three sediment replicates collected per station was analyzed for polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDDs and PCDFs) and Extractable Organics.

3.2.3 Sediment Bioassays

Sediment bioassays were conducted as described by Bedard *et al.* (1992). These utilized *Hexagenia limbata* nymphs, *Chironomus tentans* larvae and juvenile fathead minnows (*Pimephales promelas*). Both acute (mortality) and chronic (growth) endpoints were measured in the invertebrates; for the fish, only mortality was determined. Sediment obtained from Honey Harbour in Georgian Bay (the source of the *Hexagenia* used in the bioassays) was also tested as a "negative control" or background sediment.

3.3 Interpretive Framework

3.3.1 Benthic Community Data Analysis

A list of invertebrate taxa and their abundances per square meter was produced for each station replicate. Summary statistics were tabulated for each taxon and each species, indicating the number of occurrences (i.e., presences) and the total count of organisms per sample and station, including station means and standard deviations. The following community descriptors were calculated for each station:

- taxa richness (total number of taxa, mean and standard deviation);
- total abundance per m^2 for each station (mean and standard deviation);
- relative abundance and numerical dominance of taxa for each station;
- mean abundance of all major taxa (e.g., Ephemeroptera, Plecoptera, Trichoptera, Chironomidae, etc.); and
- Shannon-Wiener H' diversity index.

Potential differences in benthic invertebrate communities among stations were examined by:

- univariate ANOVAs comparing station means, followed by Tukey's multiple pairwise comparisons using both raw- and log-transformed abundance data; and
- cluster analysis performed on presence/absence data using the coefficient of community (CC) (Gauch, 1982) and on log-transformed species abundances using the Bray-Curtis coefficient (Bray and Curtis, 1957). Cluster analyses were completed for individual sample replicates and station means using Ward's Minimum Variance linkages. Cluster analyses results were verified by comparison to principal components analysis (PCA)

using Systat (Wilkinson, 1990) and by subsequent plotting of derived PC scores for both abundance and presence-absence data sets. Station groupings based on cluster analysis and PCA results were employed for subsequent discriminant analysis on environmental variables.

Benthic invertebrate communities at each of the eight stations were also examined to determine the relative abundance of taxa with reported pollution tolerance characteristics. An attempt was made, where information was available, to categorize the dominant taxa as either tolerant, moderately tolerant ("meso"-tolerant), or intolerant of pollution. In general, the sensitivities of benthic invertebrates to organic pollution and associated low dissolved oxygen conditions are relatively well established. Information is available on the tolerance of some benthic fauna to other types of pollutants (e.g., heavy metals), and in such instances this is indicated in the presentation of the results.

3.3.2 Chemistry Data Analysis

All chemistry data was summarized as mean values for each station in tabular format. Mean concentrations were compared with Provincial Sediment Chemistry Guidelines (Persaud *et al.*, 1993). Parameters having only non-detect values were not included in this summary and were eliminated from further statistical analysis.

Principal components analysis was employed to identify common patterns among chemistry variables and to derive principal components to reduce chemistry variables required for further statistical analysis (i.e., correlation and discriminant function analysis using benthic invertebrate results). Separate PCAs were completed for: (i) particle size; (ii) heavy metals; (iii) PAHs; and (iv) PCDD/F homologs and isomers. Derived PCA scores for principal components accounting for a significant portion of the total multivariate variation were plotted by station in order to identify grouping patterns among stations based on the chemistry results.

3.3.3 Toxicity Data Analysis

Station 52 sediments were not significantly different from the Honey Harbour negative control sediments in these toxicity tests (Bedard & Petro, 1997) and were therefore used as "reference" sediments in this report.

The bioassay test results were summarized as mean (± standard deviation) values in tabular format. Dunnett's t-test was used to determine statistical differences between the control and reference sediments and the other sediments for percent mortality ($p < 0.05$). Station means were compared by Tukey's HSD test for percent mortality ($p < 0.05$) and by planned comparisons using the non-parametric LSMeans test for comparing body weight data ($p < 0.01$) (Bedard &

Petro, 1997).

3.3.4 Integrated Analysis of Benthic Invertebrate, Sediment Chemistry and Bioassay Data Sets

Discriminant function analysis was used to investigate the relationships between stations based on benthic invertebrate groupings and measured environmental variables, including sediment chemistry. Variables included in the analysis were conventional parameters, particle size principal components, metals principal components, and PAH principal components.

An assessment matrix table was constructed to provide a comparative summary and interpretive framework for the combined results of benthic invertebrate community structure, sediment chemistry and sediment bioassays. Provincial Sediment Quality Guidelines (PSQGs) were employed to compare sediment contamination levels among stations. Bioassay (toxicity) results were compared to toxicity in reference (i.e., "clean") sediments to indicate potential effects. No suitable control or reference station, either in a spatial or a temporal sense, was considered appropriate for comparison of the benthic communities in this study. Therefore, "indicators" of benthic community health identified using the methods described in Section 3.3.1 were incorporated in the assessment framework in a comparative manner in order to identify possible effects on benthic communities.

4.0 RESULTS AND DISCUSSION

4.1 Benthic Invertebrate Communities

A summary of relevant benthic habitat information for each sampling station is presented in Table 1. The particle size composition of sediments is presented in Table 2. The particle size data was reduced to two principal components: (i) the first PC accounting for 71 % of the variation related to increasing sand content; and (ii) the second PC accounting for 21 % of the remaining variation differentiated between those samples containing gravel and with increasing clay content (Fig. 2). Six of the eight stations grouped together, whereas Stations 35 and 102 formed their own distinct groups due to their higher sand and clay content, respectively. Note that only one sample in the entire data set (i.e., one replicate from Station 183) contained a small amount of gravel, and this would appear to be an anomaly. Differences in (physical) habitat conditions can strongly influence the composition and structure of benthic invertebrate communities. The potential effect of habitat differences on observed benthic communities is discussed in subsequent sections of this report.

Table 1. **Sediment and biological characteristics at sampling stations.** (Based on the average of three replicate samples at each station.)

Characteristic	Station Number & Location							
	52 Point aux Pins Bay	**35 Tannery Bay**	**183 Algoma Slip**	**165 Bellevue Marine Park**	**172 Lake George Channel**	**169 Lake George Channel**	**87 Little Lake George**	**102 Lake George**
Depth, m.	4.8	0.5	2.4	2.8	1.8	6.8	2.2	15.2
Distance from CDN (US) shore, metres	2 530	-50	25	500	150	180	870	-1 275
Infrared Spectroscopy	humic acids, animal fats & lubricant oils	humic acids, animal fats & lubricant oils	coal tar & humic acids	humic acids, animal fats & lubricant oils	humic acids, animal fats & lubricant oils	humic acids, animal fats & lubricant oils	humic acids, animal fats & lubricant oils	humic acids, animal fats & lubricant oils
Visual Description	brown silt; abundant bark and wood chips	light brown over dark brown silty sand; orange particles; abundant logs and bark	silt over black, gravelly, coarse sand; over brown sand; heavy oil sheen; oil globules	gray silt over brown-gray clay; oil sheen; some fine detrital debris	silty brown ooze; abundant detritus, leaves and sticks; slight oil sheen	ooze; abundant detritus; oil sheen	brown silty clay; abundant detritus; light oil sheen	brown silty clay; small oil globules
Odour	none	none	strong petrochemical	oil & petrochemical	rotting organic (fecal) matter	rotting organic matter & petrochemical	rotting organic matter	none
Visible Fauna	mayflies, amphipods	lumbriculid, leeches	none	worm, snails, lamprey ammocoete	lamprey ammocoete	oligochaete, chironomid	oligochaetes, isopod, crayfish	oligochaetes
Visible Flora	none	patchy *Vallisneria sp.* & quillwort	none	*Elodea sp.*, *Potamogeton spp.* (60 % cover)	none	none	*Elodea sp.*, *Potamogeton spp.* (50 % cover)	none

Table 2. **Summary of sediment particle size composition at the sampling stations.** Values are presented as the mean of three replicate samples at each station.

Particle Size Distribution, Percent	**Diameter,** microns (μm)	**Station 52** Point aux Pins Bay	**Station 35** Tannery Bay	**Station 183** Algoma Slip	**Station 165** Bellevue Marine Park	**Station 172** Lake George Channel	**Station 169** Lake George Channel	**Station 87** Little Lake George	**Station 102** Lake George
Gravel	2 000 to 1 000	0	0	0.8	0	0	0	0	0
Sand	999 to 62	21.7	72.1	53.7	25.3	22.4	28	28	0.7
Silt	62 to 3.73	63.5	21.6	33.5	57.2	62.2	58.9	53.8	67
Clay	<3.73	14.8	6.29	13	17.4	15.4	13.1	18.2	32.3

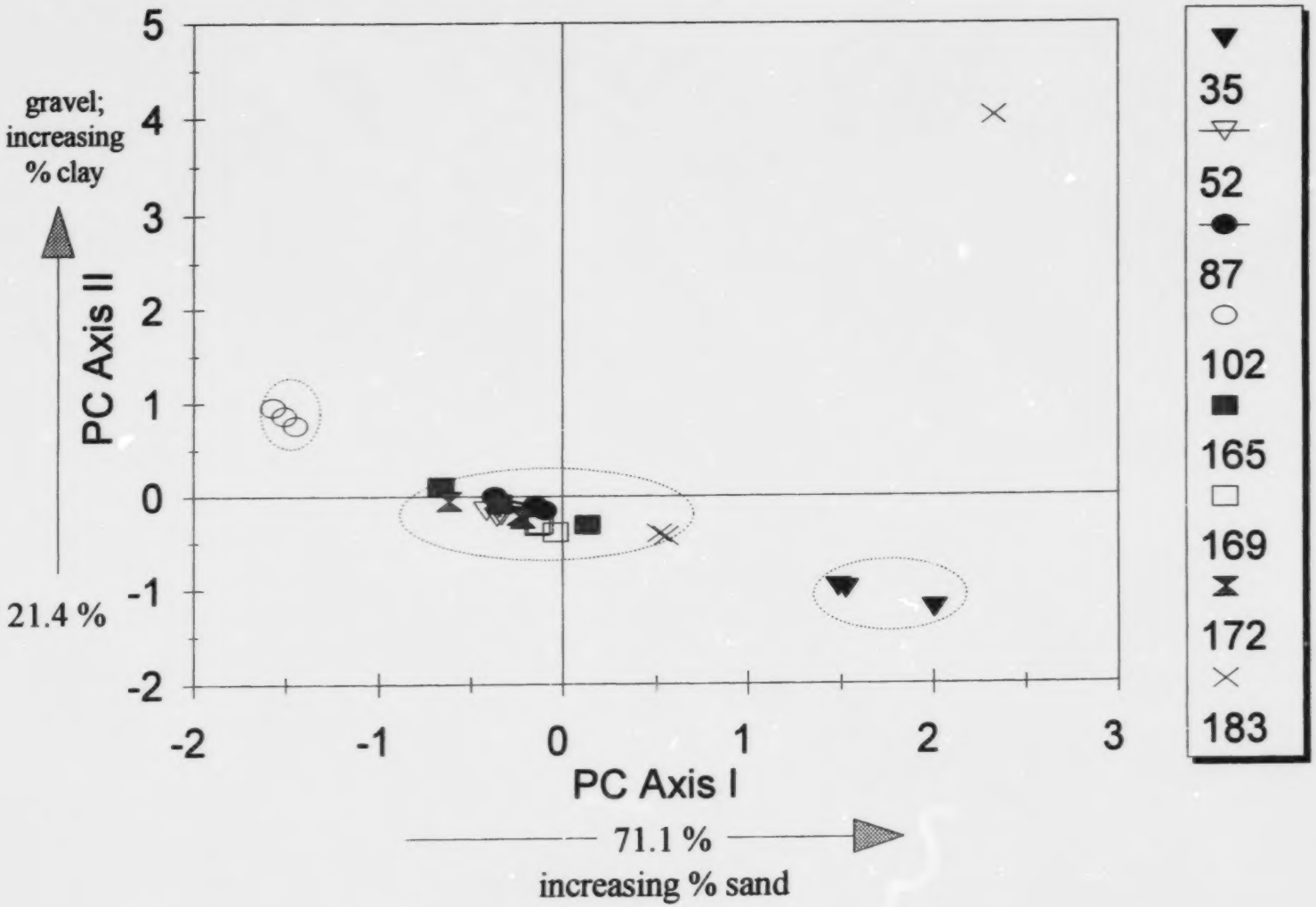

Figure 2. Summary plot of sediment particle size PCA scores.

4.1.1 Benthic Community Characteristics

The mean relative abundance of the dominant taxa at all stations is summarized in Table 3. Summary indices, including measures of community diversity are presented in Table 4 and Figure 3.

ANOVA testing indicated significant differences in the total abundance and richness of benthic invertebrate communities among stations. Note that Station 183 was excluded from the ANOVA due to the lack of variability among replicates (i.e., no organisms were found in any replicate). Stations 52 and 102 had significantly lower mean abundances ($p < 0.05$, Tukey's multiple pairwise test) compared to the other stations. Station 35 had the highest number of taxa of all the stations sampled in this study. Stations 52, 165 and 172 had significantly fewer taxa than Station 35 (Fig. 3).

Species lists for the entire benthic invertebrate collection and for each station are presented in Appendix B. Mean total abundance (number of organisms per m^2) and mean relative abundance (as %) for all species are also provided in Appendix B.

4.1.2 Cluster and Principal Components Analyses

Cluster analysis and principal components analysis consistently identified four distinct invertebrate groups from the eight stations sampled. These groupings are summarized in Table 5, along with a brief description of their distinguishing characteristics based on benthic species data. Dendrograms of cluster analysis results using the Coefficient of Community for presence-absence data and the Bray-Curtis coefficient for abundance data are presented in Figures 4 and 5.

Principal components analysis reaffirmed the cluster analysis groupings (see Figs. 6 and 7). The first two principal components in each case accounted for only about 40 % of the variation in their respective data sets, reflecting the substantial variation associated with this community data. The subsequent discussion deals only with abundance data for convenience of presentation; however, it is clear that abundance data or species presence-absence data give virtually identical results.

Station 183 (Group IV in Table 5) was most obviously different from all other stations, since no benthic invertebrates were found in any replicates. Station 35 replicates clustered as a distinct

Table 3. Mean relative abundance (as %) of taxa listed in order of dominance[1].

Station 52 Point aux Pins Bay		Station 35 Tannery Bay		Station 165 Bellevue Marine Park		Station 172 Lake George Channel		Station 169 Lake George Channel		Station 87 Little Lake George		Station 102 Lake George	
Micropsectra sp.	19.6	Enchytraeidae	17.5	*Caecidotea sp.*	46.5	tubificids - no hairs	82.8	*Slavinia appendiculata*	30.2	Nematoda	37.7	*Potamothrix vejdovskyi*	15.5
Nematoda	14.7	tubificids - hairs	12.1	tubificids - no hairs	17.2	Nematoda	12.3	tubificids - no hairs	17.8	tubificids - no hairs	13.2	*Eukieferiella sp.*	14.6
Spirosperma ferox	14.7	*Potamothrix vejdovskyi*	11.5	Nematoda	10.6	*Limnodrilus hoffmeisteri*	2.6	*Potamothrix vejdovskyi*	13.3	*Caecidotea sp.*	12.7	tubificids - no hairs	14.4
Caecidotea sp.	14.7	Nematoda	8.8	*Spirosperma ferox*	6.2	*Spirosperma ferox*	1.2	*Vejdovskyella intermedia*	13.3	*Lirceus sp.*	9.6	Nematoda	10
Pagastiella sp.	9.8	*Phaenopsectra sp.*	8.7	*Stylodrilus heringianus*	4.8	*Pristinella osborni*	0.6	*Spirosperma ferox*	7.2	*Procladius sp.*	6.4	*Aulodrilus pluriseta*	8.7
tubificids - no hairs[2]	4.9	*Stictochironomus sp.*	7.5	*Valvata sincera*	4.6	*Nais variabilis*	0.6	*Nais variabilis*	4.6	*Nais variabilis*	4.8	*Procladius sp.*	7.8
Phylocentopus sp.	4.9	*Pisidium sp.*	6.5	*Procladius sp.*	2.6			*Chironomus sp.*	4.1	*Glyptotendipes sp.*	3.9	*Slavinia appendiculata*	5.0
Procladius sp.	4.9	*Alboglossiphonia heteroclita*	4.2	*Eukieferiella sp.*	2.1			*Procladius sp.*	3.0	*Slavinia appendiculata*	2.4	Copepoda	4.8
Gammarus lacustris	4.9	*Hyalella sp.*	3.6	*Limnodrilus hoffmeisteri*	2.1			Nematoda	2.6	Tardigrada	2.4	*Vejdovskyella intermedia*	3.0
Eukieferiella sp.	4.9	*Stylodrilus heringianus*	2.8	*Nais variabilis*	2.1			Chironomid pupae	1.5	*Spirosperma ferox*	2.4	*Micropsectra sp.*	3.0
Hexagenia limbata	1.9	*Cladotanytarsus sp.*	2.2	*Chironomus sp.*	0.5			*Cladopelma sp.*	0.9	*Limnodrilus hoffmeisteri*	2.4	*Manayunkia speciosa*	2.5
		Rheotanytarsus sp.	2.1	*Pisidium sp.*	0.5			*Pisidium sp.*	0.9	*Chironomus sp.*	1.9	*Stylodrilus heringianus*	2.1
		Helobdella stagnalis	1.7	*Sparganophilus einseni*	0.1			*Ophidonais serpentina*	0.7			*Chironomus sp.*	2.0
		Chelifera sp.	1.5	*Campeloma decisum*	0.1							*Spirosperma ferox*	1.6
		Micropsectra sp.	1.5									*Chaetogaster diaphanous*	1.4
		Eukieferiella sp.	1.4									*Chelifera sp.*	1.4
		Trichorythodes sp.	1.3									*Pisidium sp.*	0.5
		Glyptotendipes sp.	0.9									*Sphaerium sp*	0.5
		Cryptochironomus sp.	0.8									*Nais variabilis*	0.5
		Cerratopogonidae	0.5									*Valvata sincera*	0.5
		Caenis sp.	0.4										
		Nais variabilis	0.4										
		Valvata sincera	0.4										
		Xenochironomus sp.	0.4										
		chironomid pupae	0.4										
		Helobdella fusca	0.2										
		Moorobdella fervida	0.2										
		Sparganophilus einseni	0.2										
		tubificids - no hairs	0.2										
		Potthastia sp	0.1										
		Sphaerium sp	0.1										
		Tanytarsus sp	0.1										

NOTES 1) Station 183 is excluded, since no benthic invertebrates were present in samples from that station
2) immature tubificids were identified as "with hairs" or with "no hairs" (with hair setae or without hair setae).

Table 4. **Mean abundance, richness and indices of diversity and evenness for benthic invertebrate communities.** Within rows, for Total Abundance and Richness, those mean values sharing a common superscript letter are not significantly different ($n = 3$; $p < 0.05$, Tukey's HSD test.) Note that Station 183 was excluded from the ANOVA, since no organisms (no variability) were present at this station.

Benthic Community Index	measure	Station 52 Point aux Pins Bay	Station 35 Tannery Bay	Station 183 Algoma Slip	Station 165 Bellevue Marine Park	Station 172 Lake George Channel	Station 169 Lake George Channel	Station 87 Little Lake George	Station 102 Lake George
Total Abundance	number.m^{-2}	1 033 ± 226 ^{a}	12 262 ± 4 351 ^{b}	0 ± 0	10 306 ± 6 188 ^{b}	14 578 ± 10 969 ^{b}	9 711 ± 527 ^{b}	4 430 ± 2 509 ^{ab}	1 249± 284 ^{a}
Richness	number of taxa	6.0 ± 1.0 ^{a}	20.7 ± 5 ^{bd}	0 ± 0	7.7 ± 2.1 ^{acd}	3.7 ± 1.5 ^{c}	9.7 ± 1.2 ^{acd}	6.0 ± 2.0 ^{a}	13.3 ± 2.5 ^{d}
Diversity	Shannon-Wiener H'	1.634 ± 0.249	2.456 ± 0.331	0 ± 0	1.272 ± 0.623	0.515 ± 0.290	1.924 ± 0.096	1.505 ± 0.159	2.275 ± 0.172
Evenness	J	0.914 ± 0.057	0.816 ± 0.073	0 ± 0	0.613 ± 0.224	0.416 ± 0.122	0.850 ± 0.003	0.870 ± 0.086	0.882 ± 0.004

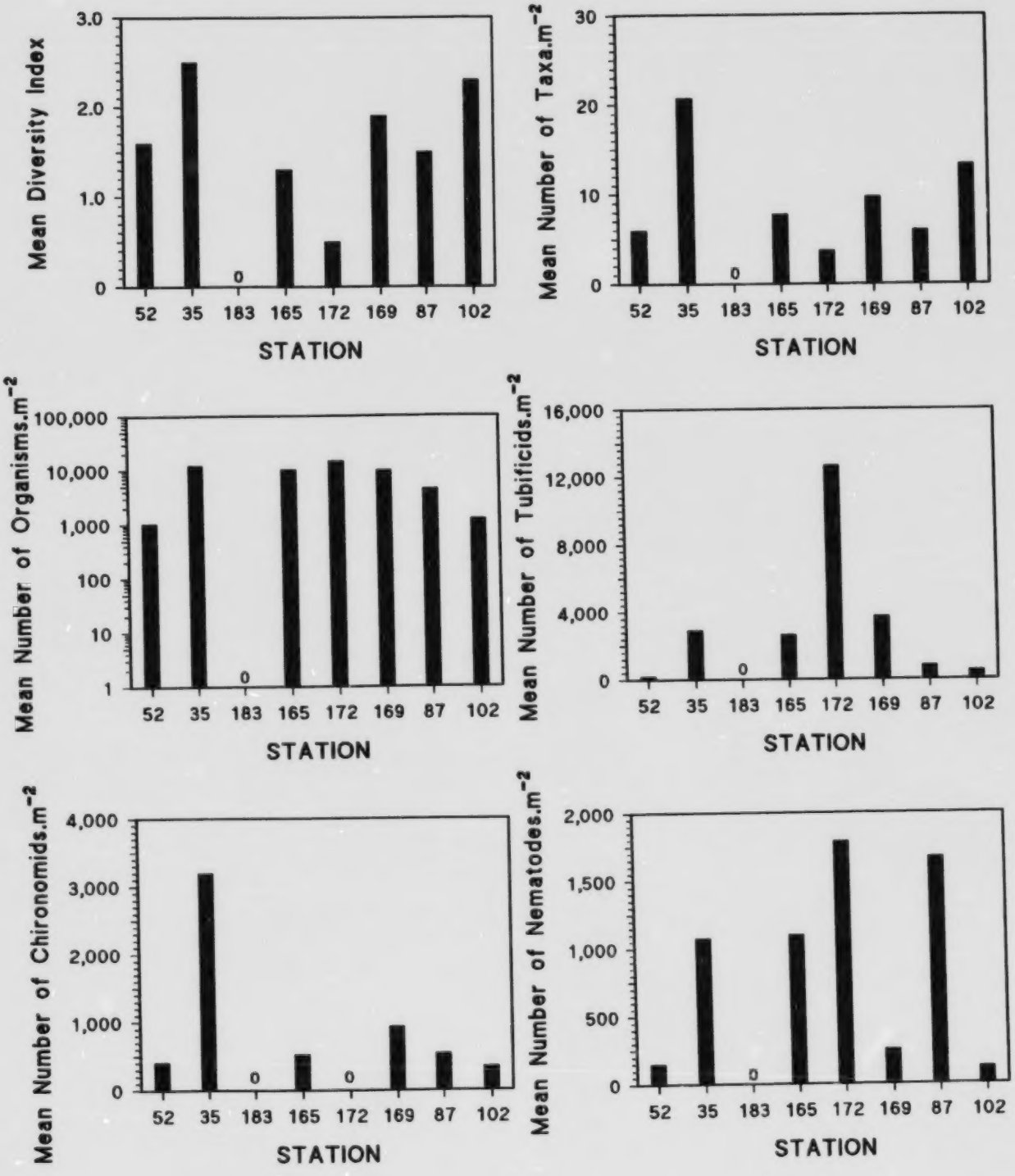

Figure 3. **Benthic invertebrate community characteristics.**

Table 5. Grouping of sampling stations according to Cluster Analysis and PCA results for benthic invertebrate community data.

Attributes	Ordination Grouping			
	I	II	III	IV
Station and sample replicates included in Grouping	35-1, 35-2, 35-3	102-1, 102-2, 102-3 169-1, 169-2, 169-3	52-1, 52-2, 52-3 87-1, 87-2, 87-3 165-1, 165-2, 165-3 172-1, 172-2, 172-3	183-1, 183-2, 183-3
Common taxa (40 % or more relative abundance)	Enchytraeidae immature tubificids (with hair setae) *Potamothrix vejdovskyi* Nematoda	*Potamothrix vejdovskyi* immature tubificids (no hair setae) *Slavinia appendiculata*	Nematoda immature tubificids (no hair setae) *Caecidotea sp.*[1]	none
Mean number of taxa	21	10	7	0
Mean total density (number.m^{-2})	12 262	5 480	7 586	0

NOTE: *Caecidotea sp.* was not present in any replicates from Station 172.

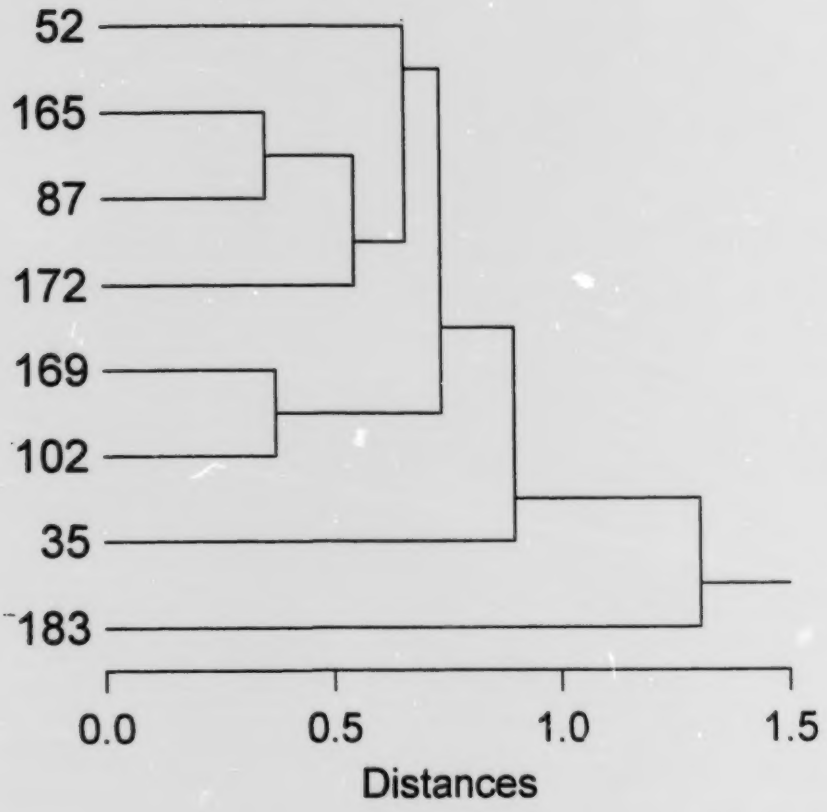

Figure 4. **Dendrogram for Wards Minimum-Variance cluster analysis of stations using Coefficient of Community (based on presence-absence data matrix) for benthic invertebrates.**

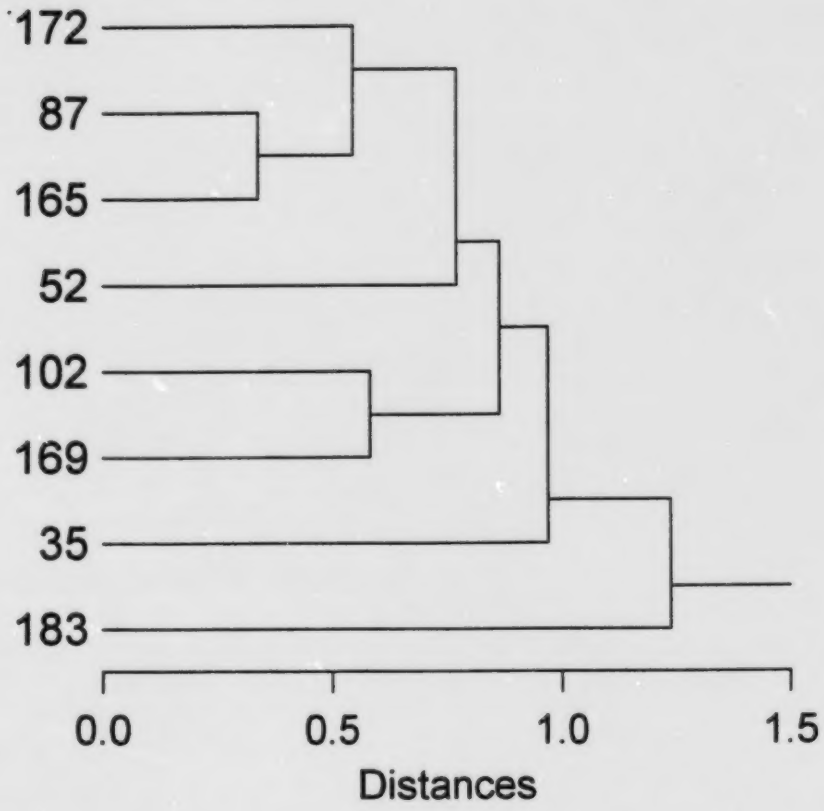

Figure 5. **Dendrogram for Wards Minimum-Variance cluster analysis of stations using Bray-Curtis Coefficient (based on abundance data matrix) for benthic invertebrates.**

group (Group I) from other stations. This station was distinguished by the presence and/or relatively higher abundance of the chironomid *Stictochironomus sp.*, the leeches *Helobdella stagnalis*, and *Alboglossiphonia heteroclita*, Enchytraeidae, and immature tubificids with hair setae. The second principal component distinguished between the two remaining groups. Stations 102 and 169 (Group II) were grouped according to the higher relative abundance of the naidids *Vejdovskyella intermedia*, and *Slavinia appendiculata*, the tubificid *Potamothrix vejdovski* and *Chironomus sp.* Stations 172, 165, 87 and 52 scored low on both PC axes and formed Group III by virtue of their lack of similarity in benthic structure to the other groups. Stations 87 and 165 clustered most tightly among this group. All four stations shared a high proportion of nematodes and immature tubificids without hair setae. The isopod *Caecidotea sp.* was a dominant taxon at all stations except for Station 172, where it was absent.

4.1.3 Indicator Species/Associations

Immature tubificids were common and among the dominant taxa at all stations. Tubificids are generally tolerant of organically polluted environments where reduced oxygen levels often result in the loss of more sensitive benthic taxa (Mason, 1981). The increased food supply and reduced competition in such organically enriched habitats typically leads to an increase in the abundance of tubificids.

Nematodes were also among the dominant taxa identified at all stations. There is a paucity of information on the ecology of nematodes in general, and the taxonomy of this group is poorly defined. Nematodes appear to prefer soft, fine substrates where they may tend to occur in the deeper layers of bottom sediments (Wetzel, 1975). As a group, they seem to be tolerant of at least moderate levels of organic pollution but may disappear in severely degraded habitats.

Ephemeropterans (mayflies) and trichopterans (caddisflies) were only found in sediments at Stations 52 and 35. Ephemeropterans, trichopterans and plecopterans (stoneflies) represent a group of insect taxa which are generally considered sensitive to pollution, especially organic enrichment and the resultant low dissolved oxygen conditions. In the St. Marys River, low densities or the complete absence of burrowing mayfly (*Hexagenia limbata*) nymphs have been correlated with the presence of visible oil in sediments (Hiltunen & Schloesser, 1983). *H. limbata* and the trichopteran *Phylocentopus sp.* were present in low numbers at Station 52. The ephemeropterans *Caenis sp.* and *Trichorythodes sp.* were found at Station 35. Ephemeropterans, trichopterans and plecopterans were absent from all other stations.

The lumbriculid worm *Stylodrilus heringianus*, which is considered to be largely intolerant of organic pollution (i.e., a clean water organism), was relatively abundant at Stations 35 and 165. This species prefers sandy to gravelly sediments, but is typically absent or reduced in numbers in

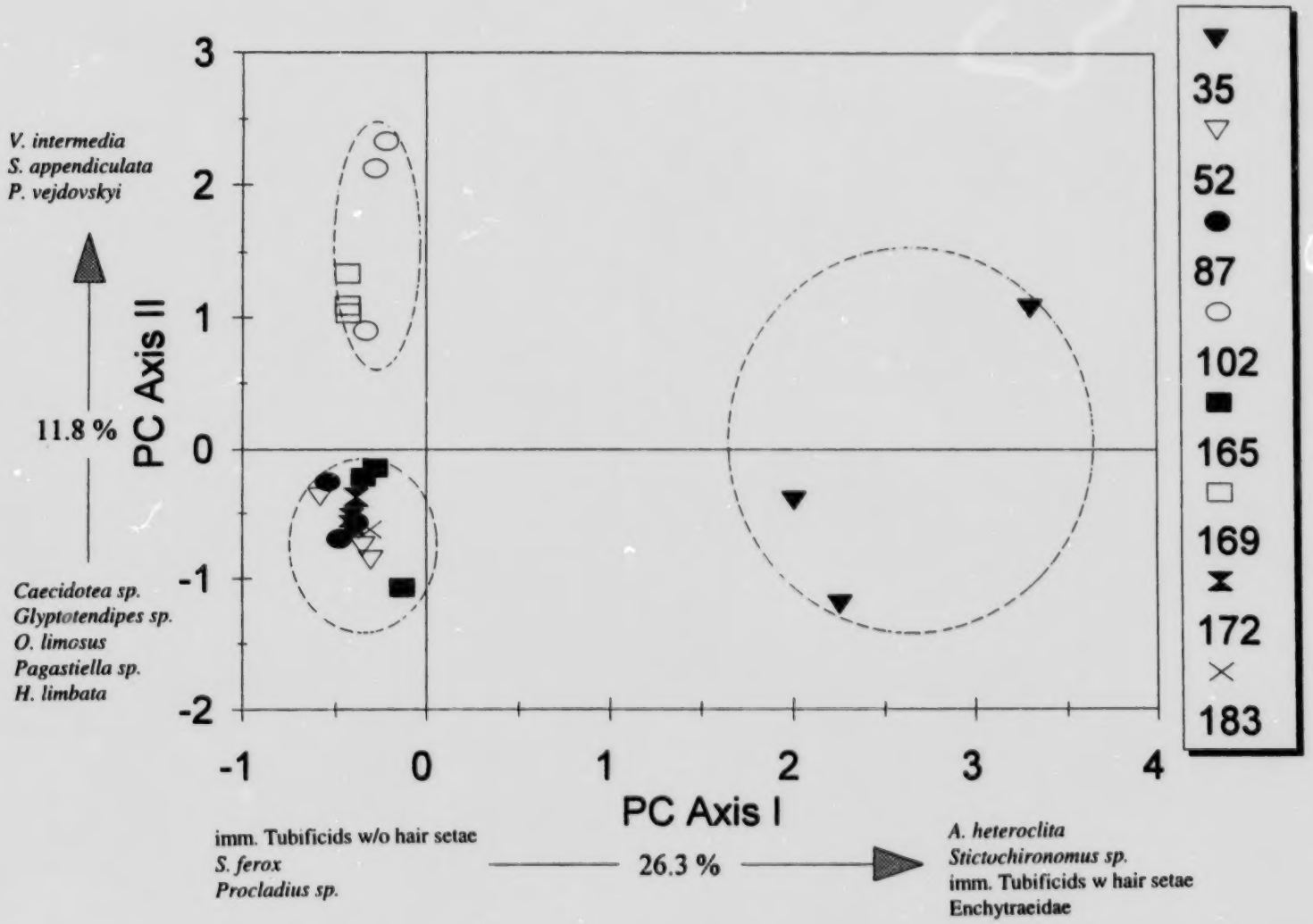

Figure 6. Summary plot of PCA results for benthic invertebrate communities using taxa presence-absence data.

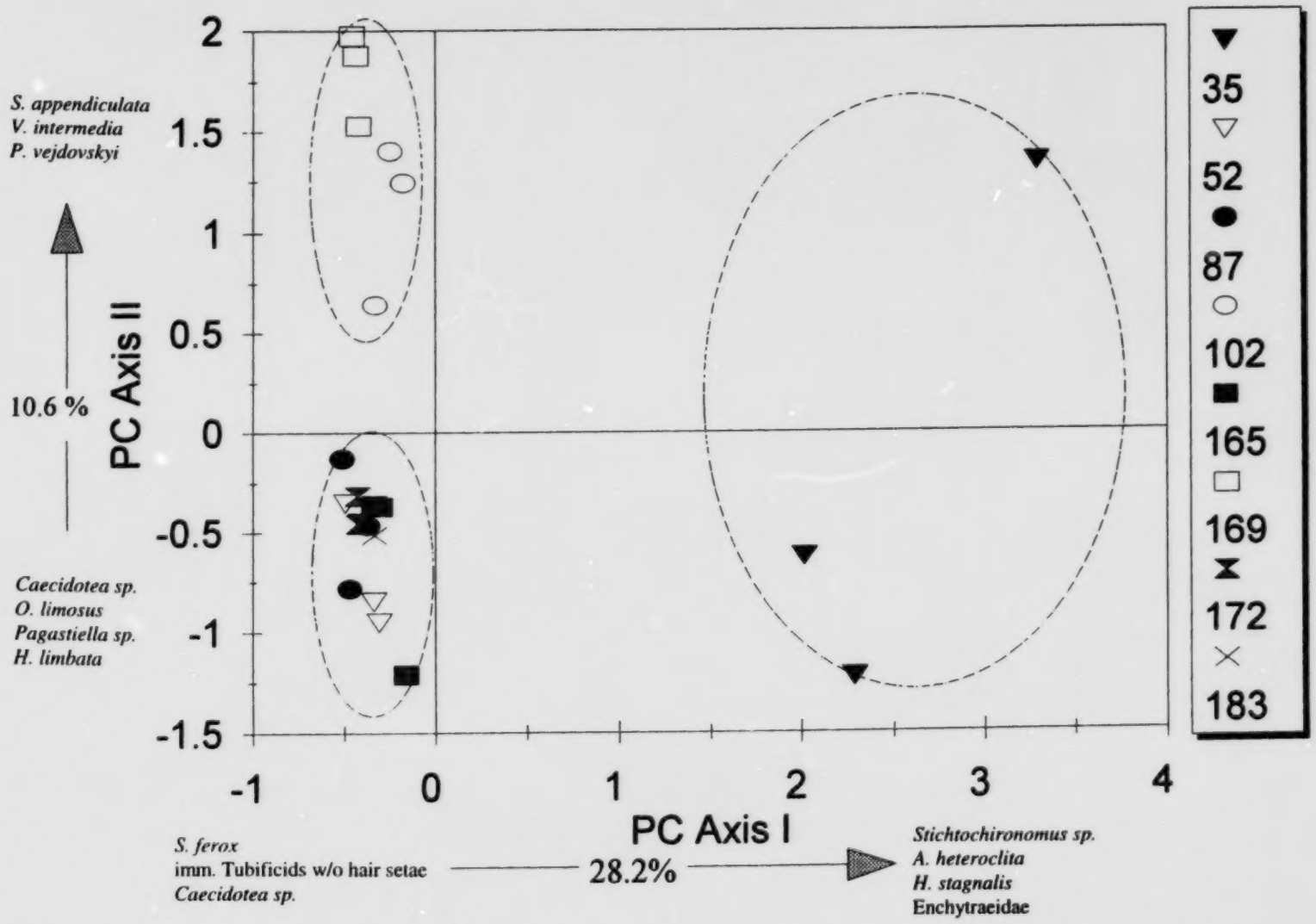

Figure 7. Summary plot of PCA results for benthic invertebrate communities using log (x+1) abundance data.

disturbed areas such as near urban centres (Nalepa & Thomas, 1976). The higher proportion of larger substrate particles (i.e., sand) may account for its greater abundance at Station 35 (see Table 2); however, Station 165 was characterized by finer substrate, similar to the other stations sampled. Therefore, particle size composition of the sediments cannot be inferred as the sole causal factor for the presence of *S. heringianus* in this study.

The isopod *Caecidotea sp.* comprised almost half the total benthic invertebrate population at Station 165. The presence of this species in association with a number of more pollutant-tolerant forms would suggest low to moderate impacts at Station 165. Another mesotrophic indicator found at this station was the gastropod (snail) *Valvata sincera.*

Stations 102 and 169 were both characterized by a moderate diversity of benthic fauna, with the common dominant taxa including nematodes, immature tubificids without hair setae, the naidids *Slavina appendiculata* and *Vejdovskyella intermedia*, the tubificid *Potamothrix vejdovskyi*, and the chironomids *Procladius sp.* and *Chironomus sp.* Throughout the Great Lakes, these taxa are generally characteristic of areas exhibiting organic enrichment (Cook & Johnson, 1974). The polychaete *Manayunkia speciosa* was only found at Station 102 in upper Lake George. This species has been associated with, and may be indicative of, moderate organic pollution (Poe & Stefan, 1975).

Station 172 exhibited a low benthic invertebrate richness and the benthic community was dominated by a very high abundance of immature tubificids without hair setae. These tubificids were most likely *Limnodrilus hoffmeisteri*, based on the presence of adult specimens at this location. This tubificid is known to be extremely tolerant of organic pollution (i.e., severe enrichment and low oxygen conditions).

4.2 Sediment Chemistry

Contaminants detected in sediment samples are summarized in Table 6 and the levels of selected contaminants are plotted in Figures 8 and 9. Since no polychlorinated biphenyls (PCBs), chlorinated aliphatics, benzenes and insecticides, or herbicides were found in river sediments above their respective analytical minimum reportable values (MRVs), these are not included in this table. However, a complete listing of contaminants and the analytical results or MRVs for individual replicates is provided in Appendix C. Sediment concentrations of total organic carbon (TOC) and total Kjeldahl nitrogen (TKN) were above the respective PSQG-LELs at all stations. Station 52 (Point aux Pins Bay) sediment, with low concentrations of most contaminants, can be considered to be relatively "clean". Of the persistent contaminants, copper, cadmium and

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Table 6. **Concentrations of nutrients, metals and persistent organic contaminants in sediments.** Values are means of three replicates analyzed per station (only 1 replicate for PCDDs and PCDFs), on dry weight basis.

Parameter	Units	Station								OME-PSQG		EC	OME-OWDMDG
		52	35	183	165	172	169	87	102	LEL	SEL *		
Calcium	$mg.kg^{-1}$	3767	2633	9967	4200	3900	3500	3767	6500	--	--		
Chloride	"	4.2	16	18.7	16.7	27	6.6	22	5.7	--	--		
Density	$g.cm^{3}$	1.2	1.5	1.4	1.2	1.2	1.2	1.4	1.3	--	--		
Redox Potential	mV	-100	14	-231	-91	-93	-123	-127	-123	--	--		
Moisture	%	59	33	28	61	58	55	51	62	--	--		
Ammonium	$mg.kg^{-1}$	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	--	--		100
Nitrogen, total Kjeldahl (TKN)	$g.kg^{-1}$	2.3	1.2	1.8	2.3	3.1	2	1.5	1.5	0.55	4.8		
Phosphorus, total (TP)	"	0.4	0.4	0.3	0.6	0.9	0.6	0.4	0.7	0.6	2		
Residue, Loss on Ignition	"	130	30	127	105	107	113	44	60	--	--		60
Solvent Extractables	$mg.kg^{-1}$	2715	697	5386	7866	6143	7117	2160	2899	--	--		1500
Carbon, total Organic (TOC)	$g.kg^{-1}$	59.7	15.3	**192**	77	64	75.3	22.3	31	10	100		
Aluminum	$mg.kg^{-1}$	6100	2967	6167	8433	7767	6867	7300	16000	--	--		
Arsenic (As)	"	4.4	6.3	8.9	15.3	12.0	14.3	5.1	8.0	6	33		
Barium	"	30	48	42.3	43.7	60	38.3	39.3	79.7	--	--		
Cyanide, available	"	<0.01	<0.01	0.5	2.1	0.1	0.4	0.1	0.4	--	--		0.1
Cadmium (Cd)	"	1.0	0.9	0.8	1.0	0.6	0.7	0.4	0.6	0.6	10		
Cobalt	"	3.6	2	6	7.6	6.3	6.9	5.6	10.7	--	--		50
Chromium (Cr)	"	19	**2600**	28.0	73.7	81.3	57.7	25.7	47.3	26	110		
Copper (Cu)	"	26.0	11.9	28.0	55.3	57.7	54.7	22.3	41.7	16	110		
Iron (Fe)	"	7867	6533	21000	**55000**	**44000**	**50333**	16667	31333	20000	40000		
Lead (Pb)	"	17.7	49.3	27.7	62.0	87.3	71.7	30.3	49.3	31	250		
Mercury (Hg)	"	0.04<T	0.58	0.04<T	0.15	0.41	0.20	0.07	0.10	0.20	2		
Magnesium	"	2200	1120	4100	3900	2967	3067	2967	6933	--	--		
Manganese (Mn)	"	100	94	767	567	373	557	227	410	460	1100		
Nickel (nl)	"	8.9	4.5	13	29.0	22.3	27.0	14.7	29.3	16	75		
Selenium	"	0.7	0.5	1.9	1.5	1.8	1.6	0.7	1.7	--	--		
Silver	"	<0.05	<0.05	<0.05	0.1	0.8	0.3	0.1	0.2	--	--		0.5
Vanadium	"	22.7	14	26	36.7	32	30.3	27	50.3	--	--		
Zinc (Zn)	"	46	73	107	190	243	223	102	170	120	820		

Table 6. **Concentrations of nutrients, metals and persistent organic contaminants in sediments.** Values are means of three replicates analyzed per station (only 1 replicate for PCDDs and PCDFs), on dry weight basis.

Parameter	Units	Station								OME-PSQG		EC	OME-OWDMDG
		52	35	183	165	172	169	87	102	LEL	SEL *		
Calcium	mg kg^{-1}	3767	2633	9967	4200	3900	3500	3767	6500	--	--		
Chloride	"	4 2	16	18 7	16 7	27	6 6	22	5 7	--	--		
Density	g cm^{-3}	1 2	1 5	1 4	1 2	1 2	1 2	1 4	1 3	--	--		
Redox Potential	mV	-100	14	-231	-91	-93	-123	-127	-123	--	--		
Moisture	%	59	33	28	61	58	55	51	62	--	--		
Ammonium	mg kg^{-1}	0 1	0 1	0 1	0 1	0 2	0 1	0 1	0 1	--	--		100
Nitrogen, total Kjeldahl (TKN)	g kg^{-1}	2 3	1 2	1 8	2 3	3 1	2	1 5	1 5	0 55	4 8		
Phosphorus, total (TP)	"	0 4	0 4	0 3	0 6	0 9	0 6	0 4	0 7	0 6	2		
Residue, Loss on Ignition	"	130	30	127	105	107	113	44	60	--	--		60
Solvent Extractables	mg kg^{-1}	2715	697	5386	7 866	6143	7117	2160	2899	--	--		1500
Carbon, total Organic (TOC)	g kg^{-1}	59 7	15 3	**192**	77	64	75 3	22 3	31	10	100		
Aluminum	mg kg^{-1}	6100	2967	6167	8433	7767	6867	7300	16000	--	--		
Arsenic (As)	"	4 4	6 3	8 9	15 3	12 0	14 3	5 1	8 0	6	33		
Barium	"	30	48	42 3	43 7	60	38 3	39 3	79 7	--	--		
Cyanide, available	"	< 0 01	< 0 01	0 5	2 1	0 1	0 4	0 1	0 4	--	--		0 1
Cadmium (Cd)	"	1 0	0 9	0 8	1 0	0 6	0 7	0 4	0 6	0 6	10		
Cobalt	"	3 6	2	6	7 6	6 3	6 9	5 6	10 7	--	--		50
Chromium (Cr)	"	19	**2600**	28 0	73 7	81 3	57 7	25 7	47 3	26	110		
Copper (Cu)	"	26 0	11 9	28 0	55 3	57 7	54 7	22 3	41 7	16	110		
Iron (Fe)	"	7867	6533	21000	**55000**	**44000**	**50333**	16667	31333	20000	40000		
Lead (Pb)	"	17 7	49 3	27 7	62 0	87 3	71 7	30 3	49 3	31	250		
Mercury (Hg)	"	0 04< 1	0 58	0 04< 1	0 15	0 41	0 20	0 07	0 10	0 20	2		
Magnesium	"	2200	1120	4100	3900	2967	3067	2967	6933	--	--		
Manganese (Mn)	"	100	94	767	567	373	557	227	410	460	1100		
Nickel (Ni)	"	8 9	4 5	13	29 0	22 3	27 0	14 7	29 3	16	75		
Selenium	"	0 7	0 5	1 9	1 5	1 8	1 6	0 7	1 7	--	--		
Silver	"	< 0 05	< 0 05	< 0 05	0 1	0 8	0 3	0 1	0 2	--	--		0 5
Vanadium	"	22 7	14	26	36 7	32	30 3	27	50 3	--	--		
Zinc (Zn)	"	46	73	107	190	243	223	102	170	120	820		

Parameter	Units	Station 52	35	183	165	172	169	87	102	OME-PSQG LEL	SEL *	EC	OME-OWDMDG
Acenaphthene	mg kg^{-1}	<0.020	<0.020	7.338	0.153	0.058	0.075	0.02	0.02	--	--		
Acenaphthylene	"	<0.020	<0.020	0.956	0.136	0.143	0.128	0.025	0.021	--	--		
Anthracene (Anth)	"	<0.020	<0.020	13.293	0.251	0.103	0.197	0.028	0.038	0.22	370		
Benzo(a)anthracene (BaA)	"	0.03	0.046	14.120	0.972	0.829	1.251	0.196	0.388	0.32	1480		
Benzo(b)fluoranthene	"	0.06	0.052	6.419	1.071	1.118	1.261	0.268	0.55	--	--		
Benzo(k)fluoranthene (BkF)	"	0.045	0.046	7.981	0.812	0.990	1.143	0.214	0.441	0.24	1340		
Benzo(g,h,i)perylene (BghiP)	"	0.048	0.044	2.2	0.611	0.777	0.721	0.189	0.376	0.17	320		
Benzo(a)pyrene (BaP)	"	0.03	0.028	5.000	0.727	0.566	0.850	0.221	0.519	0.37	1440		
Chrysene (Chry)	"	0.054	0.06	12.322	1.104	1.089	1.322	0.219	0.396	0.34	460		
Dibenzo(a,h)anthracene (DahA)	"	<0.040	<0.040	0.340	0.172	0.215	0.099	0.066	0.103	0.06	130		
Fluoranthene (Flan)	"	0.126	0.113	77.009	2.285	1.738	2.335	0.307	0.521	0.75	1020		
Fluorene (Fluor)	"	0.224	0.097	11.337	0.206	0.073	0.117	0.021	0.021	0.19	160		
Indeno(1,2,3-cd)pyrene (IP)	"	0.047	0.045	2.492	0.617	0.805	0.719	0.230	0.540	0.2	320		
Naphthalene	"	0.065	0.044	13.437	2.517	0.301	0.908	0.092	0.136	--	--		
Phenanthrene (Phen)	"	0.071	0.067	64.682	1.244	0.641	0.969	0.122	0.22	0.56	950		
Pyrene (Pyr)	"	0.072	0.093	52.802	1.708	1.346	1.842	0.257	0.456	0.49	850		
Total of 16 PAHs (TPAHs)	"	0.97	0.836	291.7	14.59	10.79	13.94	2.474	4.746	4	10000		
Tetrachlordibenzo-*p*-dioxins (T_4CDD)	ng kg^{-1}	5.3	1.9	<2	<2	19	5.3	3.9	6.5	--	--	--	
Pentachlordibenzo-*p*-dioxins (P_5CDD)	"	3.1	4	<2	17	22	4.4	2	3.5	--	--	--	
Hexachlorodibenzo-*p*-dioxins (H_6CDD)	"	<8	12	20	70	49	28	<9	18	--	--	--	
Heptachlorodibenzo-*p*-dioxins (H_7CDD)	"	16	69	130	170	120	100	54	130	--	--	--	
Octachlorodibenzo-*p*-dioxins (O_8CDD)	"	41	250	410	460	360	590	170	370	--	--	--	
Tetrachlorodibenzofurans (T_4CDF)	"	11	<2	7.9	8	33	34	17	34	--	--	--	
Pentachlorodibenzofurans (P_5CDF)	"	5.1	<2	6.3	14	60	5.7	6	12	--	--	--	
Hexaachlorodibenzofurans (H_6CDF)	"	<3	<3	19	<20	120	19	<6	<10	--	--	--	
Heptachlorodibenzofurans (H_7CDF)	"	<8	27	34	61	49	45	20	35	--	--	--	
Octachlorodibenzofurans (O_8CDF)	"	<20	19	30	71	<20	36	<10	<40	--	--	--	
2,3,7,8-T_4CDD	"	<1	1.9	<2	<2	3	2.3	1.7	4.2	--	--	--	
1,2,3,7,8-P_5CDD	"	<1	<1	<2	4.1	1.9	<1	<1	<3	--	--	--	
1,2,3,4,7,8-H_6CDD	"	<8	<1	<3	<10	<6	<3	<9	<10	--	--	--	
1,2,3,6,7,8-H_6CDD	"	<8	<2	<4	<10	<6	<3	<8	<10	--	--	--	
1,2,3,7,8,9-H_6CDD	"	<8	<2	<3	<10	<6	<3	<9	<10	--	--	--	
1,2,3,4,6,7,8-H_7CDD	"	8.1	36	61	88	64	53	27	65	--	--	--	
2,3,7,8-T_4CDF	ng kg	2.1	<2	4.6	8	6.2	6.9	3.8	7	--	--	--	

Parameter	Units	Station								OME-PSQG		EC	OME-OWDMDG
		52	35	183	165	172	169	87	102	LEL	SEL *		
Acenaphthene	mg.kg^{-1}	<0.020	<0.020	7.338	0.153	0.058	0.075	0.02	0.02	--	--		
Acenaphthylene	"	<0.020	<0.020	0.956	0.136	0.143	0.128	0.025	0.021	--	--		
Anthracene (Anth)	"	<0.020	<0.020	13.293	0.251	0.103	0.197	0.028	0.038	0.22	370		
Benzo(a)anthracene (BaA)	"	0.03	0.046	14.120	0.972	0.829	1.251	0.196	0.388	0.32	1480		
Benzo(b)fluoranthene	"	0.06	0.052	6.419	1.071	1.118	1.261	0.268	0.55	--	--		
Benzo(k)fluoranthene (BkF)	"	0.045	0.046	7.981	0.813	0.990	1.143	0.214	0.441	0.24	1340		
Benzo(g,h,i)perylene (BghiP)	"	0.048	0.044	2.2	0.611	0.777	0.721	0.189	0.376	0.17	320		
Benzo(a)pyrene (BaP)	"	0.03	0.028	5.000	0.727	0.566	0.850	0.221	0.519	0.37	1440		
Chrysene (Chry)	"	0.054	0.06	12.322	1.104	1.089	1.322	0.219	0.396	0.34	460		
Dibenzo(a,h)anthracene (DahA)	"	<0.040	<0.040	0.340	0.172	0.215	0.099	0.066	0.103	0.06	130		
Fluoranthene (Flan)	"	0.126	0.113	77.009	2.285	1.738	2.335	0.307	0.521	0.75	1020		
Fluorene (Fluor)	"	0.224	0.097	11.337	0.206	0.073	0.117	0.021	0.021	0.19	160		
Indeno(1,2,3-cd)pyrene (IP)	"	0.047	0.045	2.492	0.617	0.805	0.719	0.230	0.540	0.2	320		
Naphthalene	"	0.065	0.044	13.437	2.517	0.301	0.908	0.092	0.136	--	--		
Phenanthrene (Phen)	"	0.071	0.067	64.682	1.244	0.641	0.969	0.122	0.22	0.56	950		
Pyrene (Pyr)	"	0.072	0.093	52.802	1.708	1.346	1.842	0.257	0.456	0.49	850		
Total of 16 PAHs (TPAHs)	"	0.97	0.836	291.7	14.59	10.79	13.94	2.474	4.746	4	10000		
Tetrachlordibenzo-*p*-dioxins (T_4CDD)	ng.kg^{-1}	5.3	1.9	<2	<2	19	5.3	3.9	6.5	--	--	--	
Pentachlordibenzo-*p*-dioxins (P_5CDD)	"	3.1	4	<2	17	22	4.4	2	3.5	--	--	--	
Hexachlorodibenzo-*p*-dioxins (H_6CDD)	"	<8	12	20	70	49	28	<9	18	--	--	--	
Heptachlorodibenzo-*p*-dioxins (H_7CDD)	"	16	69	130	170	120	100	54	130	--	--	--	
Octachlorodibenzo-*p*-dioxins (O_8CDD)	"	41	250	410	460	360	590	170	370	--	--	--	
Tetrachlorodibenzofurans (T_4CDF)	"	11	<2	7.9	8	33	34	17	34	--	--	--	
Pentachlorodibenzofurans (P_5CDF)	"	5.1	<2	6.3	14	60	5.7	6	12	--	--	--	
Hexaachlorodibenzofurans (H_6CDF)	"	<3	<3	19	<20	120	19	<6	<10	--	--	--	
Heptachlorodibenzofurans (H_7CDF)	"	<8	27	34	61	49	45	20	35	--	--	--	
Octachlorodibenzofurans (O_8CDF)	"	<20	19	30	71	<20	36	<10	<40	--	--	--	
2,3,7,8-T_4CDD	"	<1	1.9	<2	<2	3	2.3	1.7	4.2	--	--	--	
1,2,3,7,8-P_5CDD	"	<1	<1	<2	4.1	1.9	<1	<1	<3	--	--	--	
1,2,3,4,7,8-H_6CDD	"	<8	<1	<3	<10	<6	<3	<9	<10	--	--	--	
1,2,3,6,7,8-H_6CDD	"	<8	<2	<4	<10	<6	<3	<8	<10	--	--	--	
1,2,3,7,8,9-H_6CDD	"	<8	<2	<3	<10	<6	<3	<9	<10	--	--	--	
1,2,3,4,6,7,8-H_7CDD	"	8.1	36	61	88	64	53	27	65	--	--	--	
2,3,7,8-T_4CDF	ng.kg^{-1}	2.1	<2	4.6	8	6.2	6.9	3.8	7	--	--	--	

Parameter	Units	Station								OME-PSQG		EC	OME-OWDMDG
		52	35	183	165	172	169	87	102	LEL	SEL *		
1,2,3,7,8-P_5CDF	"	<2	<2	<4	<4	<2	<1	<2	<3	--	--	--	
2,3,4,7,8-P_5CDF	"	<2	<2	<4	<4	<2	<2	<2	<3	--	--	--	
1,2,3,4,7,8-H_6CDF	"	<4	<3	<4	<10	<7	<2	<6	<10	--	--	--	
1,2,3,6,7,8-H_6CDF	"	<4	<3	<4	<10	<7	<2	<6	<10	--	--	--	
2,3,4,6,7,8-H_6CDF	"	<5	<3	<4	<20	<7	<2	<6	<10	--	--	--	
1,2,3,7,8,9-H_6CDF	"	<5	<3	<4	<20	<7	<2	<6	<10	--	--	--	
1,2,3,4,6,7,8-H_7CDF	"	<8	14	13	29	16	15	8	15	--	--	--	
1,2,3,4,7,8,9-H_7CDF	"	<8	<2	<5	<10	<4	<5	<4	<9	--	--	--	
Total 2,3,7,8-T4CDD TEQ	"	0.3	2.7	1.6	4.6	5.7	4.3	2.6	6.1	--	--	--	
Total 2,3,7,8-T4CDD TEQ @ 1% TOC	"	0.05	1.93	0.08	0.63	0.93	0.61	1.13	1.61	--	-	1.7	

NOTES: Underlined value in shaded cell exceeds Provincial Sediment Quality Lowest Effect Level Guideline (PSQG-LEL) or Open Water Dredged Material Disposal Guideline(OWDMDG).
Values in **bold** type equal or exceed the Provincial Sediment Quality Severe Effect Level Guideline (PSQG-SEL)
* N.B. for PAHs the PSQG-SEL is multiplied by the station TOC (as decimal fraction) and compared to field PAH concentration.

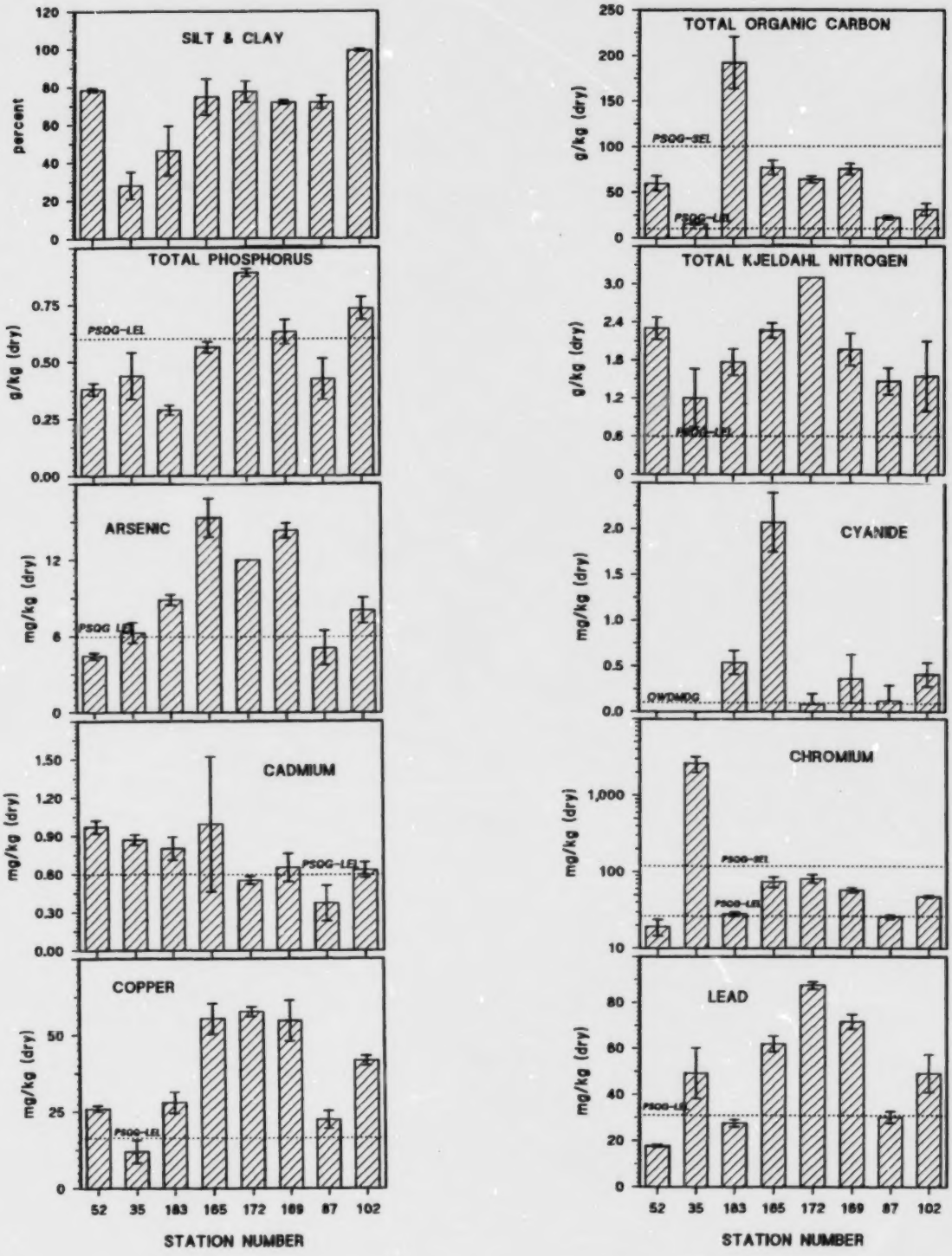

Figure 8. **Mean percent silt and clay and concentrations of total organic carbon, total phosphorus, total Kjeldahl nitrogen, arsenic, cyanide, cadmium, chromium, copper and lead in sediments.** Vertical lines on bars represent one standard deviation for replicates (n = 3).

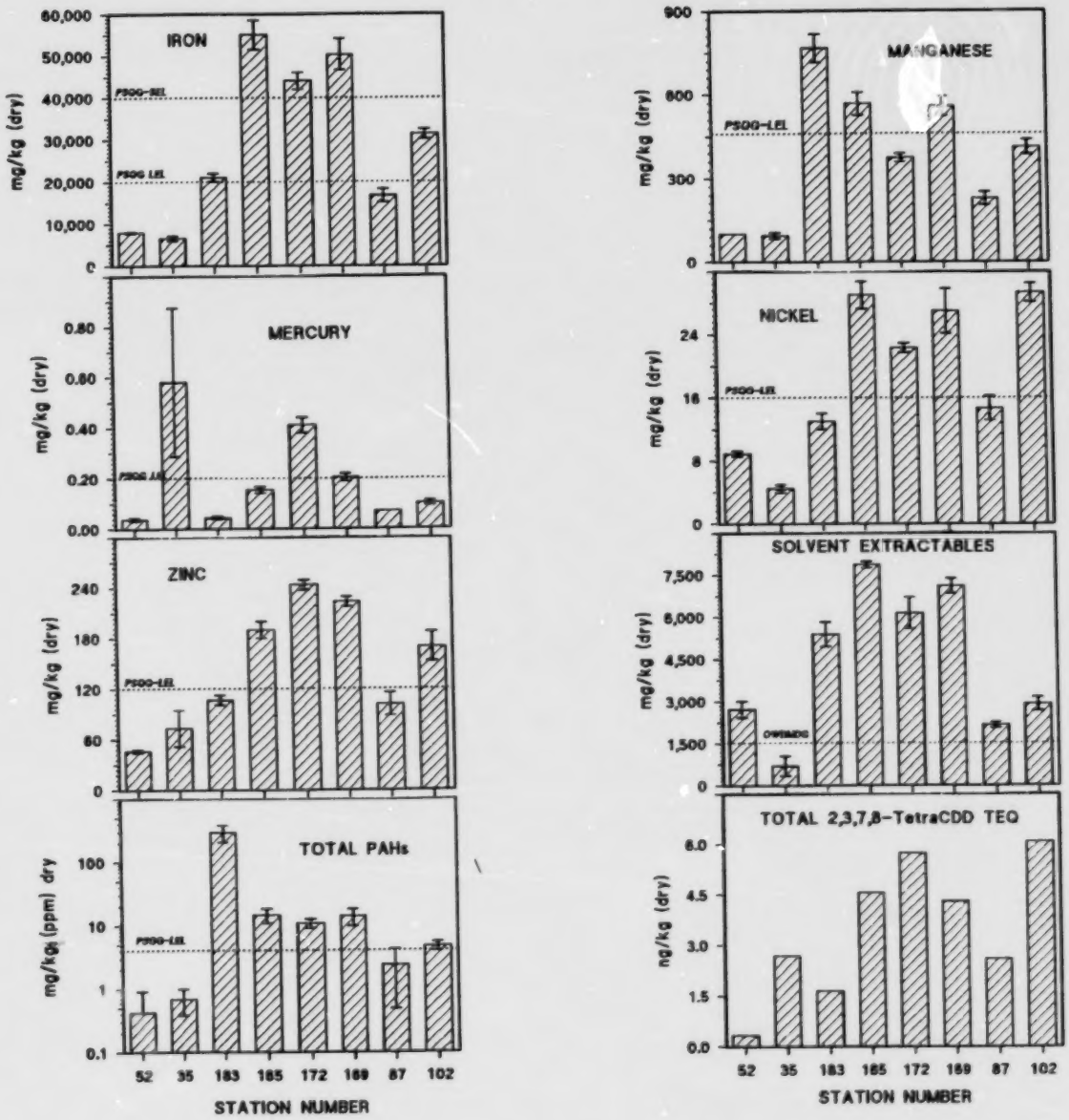

Figure 9. **Mean concentrations of iron, manganese, mercury, nickel, zinc, solvent extractables, total PAHs and Total 2,3,7,8-TetraCDD TEQ in sediments.** Vertical lines on bars represent one standard deviation for replicates (n = 3).

Table 7. **Concentrations of GC/MS-identified extractable organics in sediments.** All values are approximate, in $mg.kg^{-1}$ (ppm), dry sediment.

Compound	Station							
	52	35	183	165	172	169	87	102
Aliphatics:								
1-Hexen-3-one, 5-methyl-1-phenyl			6.0	3.0	2.0	2.0		
a methyl phenyl Hexanone		9.0						
1-Penten-3-one, 1-Phenyl		0.3						
unidentified bicyclic hydrocarbon				3.0				
unidentified hydrocarbon(s)	14.0 [5]	3.7 [8]	53.8 [20]	43.8 [20]	55.3 [28]	23.1 [18]	11.0 [7]	18.1 [11]
Aromatics:								
a C_3 alkyl Benzene			2.0					
a C_5 alkyl Benzene		0.3						
1,1'-(1,2-ethanediyl)bis-Benzene			10					
1,1'-etheneylidenbis-Benzene								3.0
1,1'[thiobis(methylene)]bis-Benzene	3.0			5.0	5.0	7.0		
an unidentified aromatic hydrocarbon			1.0					
Polycyclic Aromatics (PAHs):								
Acenaphthene			10					
Acenaphthylene			2.0					
Anthracene			10					
Benzo(a)anthracene			10					
Benzo(a)anthracene / Chrysene		0.6						
Benzofluorenes			21 [4]		5.0 [2]			
a Benzopyrene								2.0
Benzopyrenes / Benzofluoranthenes			9.0 [3]					
an 11H-Benzofluorene								1.0
Chrysene			10					
a Chrysene-type PAH								0.6
Fluoranthene		2.0	40	4.0	3.0	2.0	0.9	1.0
9H-Fluorene			10					
Naphthalene		0.2	20	3.0	0.8	2.0		1.0
Phenanthrene			50					
Phenanthrene / Anthracene				0.3	0.3			1.0
Pyrene			40	8.0	5.0	2.0		4.0
1,1'-Biphenyl			3.0					
methyl 1,1'-Biphenyls			1.9 [2]					
C_3 alkyl Biphenyls			3.0 [2]					
unidentified PAHs			10 [3]					
Methylated PAHs:								
a C_2 alkenyl Anthracene				0.2				
an ethenyl Anthracene / Phenanthrene			1.0					
a methyl Chrysene / Benzo(a) anthracene			3.0					
a methyl 9H-Fluorene			2.0					

Compound	Station							
	52	35	183	165	172	169	87	102
C_2 alkyl Naphthalenes			8.9 [4]					
a C_3 alkyl Naphthalene			2.0					
methyl Naphthalenes			7.0 [2]					
a phenyl Naphthalene			3.0					
dihydro Phenanthrene(s)			5.0 [2]				1.0 [1]	
a C_4 alkyl Phenanthrene				6.0				
a tetramethyl Phenanthrene	2.0							
methyl Anthracenes / Phenanthrenes			10 [3]					
4H-Cyclopenta(d,e,f)Phenanthrene			10					
C_2 alkyl Phenanthrenes / Anthracenes			8.0 [3]					
a methyl Pyrene / Fluoranthene			2.0					
C_4 alkyl Pyrenes / Fluoranthenes			9.0 [2]					
Sulphur-containing PAHs:								
Benzo(b)thiophene			4.0					
Dibenzothiophene			6.0					
a methyl Dibenzothiophene			1.0					
Nitrogen-containing PAHs:								
9H-Carbazole			7.0					
Oxygen-containing PAHs:								
a methyl dihydrophenyl Benzofuran			1.0					
Dibenzofuran			8.0					
methyl Dibenzofurans			6.0 [2]					
Benz(b)naphtho(2,3-d)furan			2.0					
Miscellaneous:								
a methoxy Benzene Methanol							2.0	
an ester				1.0				
a methyl ester				1.0	1.0			
a Dichlorohydroxybenzaldehyde			0.4					
1-Phenanthrene carboxaldehyde, 1,2,3,4,4,a				7.0				
a Carboxylic Acid						1.0		
a C_{16} Carboxylic Acid					2.0			
methyl esters of a C_{16} Carboxylic Acid		1.3 [2]					0.4	
a fatty acid				2.0				
a steroid		0.7						
unidentified compounds	52 [7]	6.5 [6]	3.0 [9]	33	19	19 [14]	2.3 [3]	3.7 [3]

NOTES:

1) all concentrations are approximate, relative to the d_{10}-Phenanthrene internal standard.

2) blank space indicates that compound was not detected.

3) numbers in superscripts after concentration indicate the number of distinct isomers or compounds identified.

fluorene were the only parameters exceeding the respective PSQG-LELs. Station 35 (Tannery Bay) sediment generally had low levels of contaminants as well; however, the mean concentration of chromium, at 2600 $mg.kg^{-1}$ (parts per million), was 24 times higher than the PSQG-SEL (Fig. 8). Arsenic, cadmium, lead and mercury levels also exceeded the respective PSQG-LELs. Iron concentrations exceeded the SEL guideline in Bellevue Marine Park (Station 165), and in Lake George Channel (Stations 169 and 172). The LEL Guidelines for chromium, copper, manganese, nickel and zinc were also exceeded at Stations 183, 165, 172, 169 , 87 (Little Lake George), and 102 (Lake George). Mercury only exceeded the PSQG-LEL at Stations 183, 172, and 169. Cyanide was also above the Provincial Open Water Dredged Material Disposal Guideline (OWDMDG) in sediments from the Algoma Slip and downstream of the Falls. Barium, cobalt, magnesium, selenium, silver and vanadium concentrations also increased noticeably at these stations (Table 6)

Sediment at all locations except Station 35 exceeded at least one PSQG-LEL for a PAH compound. In addition, sediments at Stations 183, 165, 172, 169 and 102 all exceeded the LEL guideline for Total PAHs of 4 $mg.kg^{-1}$ (Fig. 9). None of the stations had sediment concentrations exceeding the SEL guideline for any of the 16 unsubstituted PAH compounds measured (Table 6). However, the Total PAHs concentration at Station 183 (292 $mg.kg^{-1}$), was 300 times that found in Station 52 or 35 sediments. The 1990 Ministry study involving the collection of sediment cores from the Algoma Slip found some areas (particularly the upper, or northwest end) with PAH concentrations above the respective PSQG-SELs. At that time, concentrations of Total PAHs within the slip ranged from 9.3 to 1386 $mg.kg^{-1}$, and at Station 183 it averaged 686 $mg.kg^{-1}$ (Pope & Kauss, 1995).

Although there is no PSQG for solvent extractables (oils and greases), the OWDMDG of 1500 $mg.kg^{-1}$ was exceeded in all sediments but those from Station 35.

Table 7 summarizes the results of full-scan GC/MS analysis for extractable organics. These data indicate the presence of a large number of hydrocarbons - principally aromatics - in the sediments, particularly in the Algoma Slip (Station 183). Many alkyl-, sulphur-, nitrogen- and oxygen-containing PAHs which cannot currently be routinely analyzed for were also detected at this station, and concentrations were usually highest here as well. Some of these compounds may be exerting a toxic effect on benthic invertebrates.

Using PCA, the first two principal components explained 69 % of the variation in metals concentrations among stations. PC score plots on these two axes indicate four groups based on metals chemistry (Fig. 10) PC I separates stations based on increasing concentrations of nickel, copper, cobalt, iron and zinc. PC II differentiates stations based on increasing lead and mercury concentrations. A negative correlation (Pearson Product Moment correlation, $r = -0.599$) was observed between PC I for grain size and PC I for metals suggesting some influence of percent

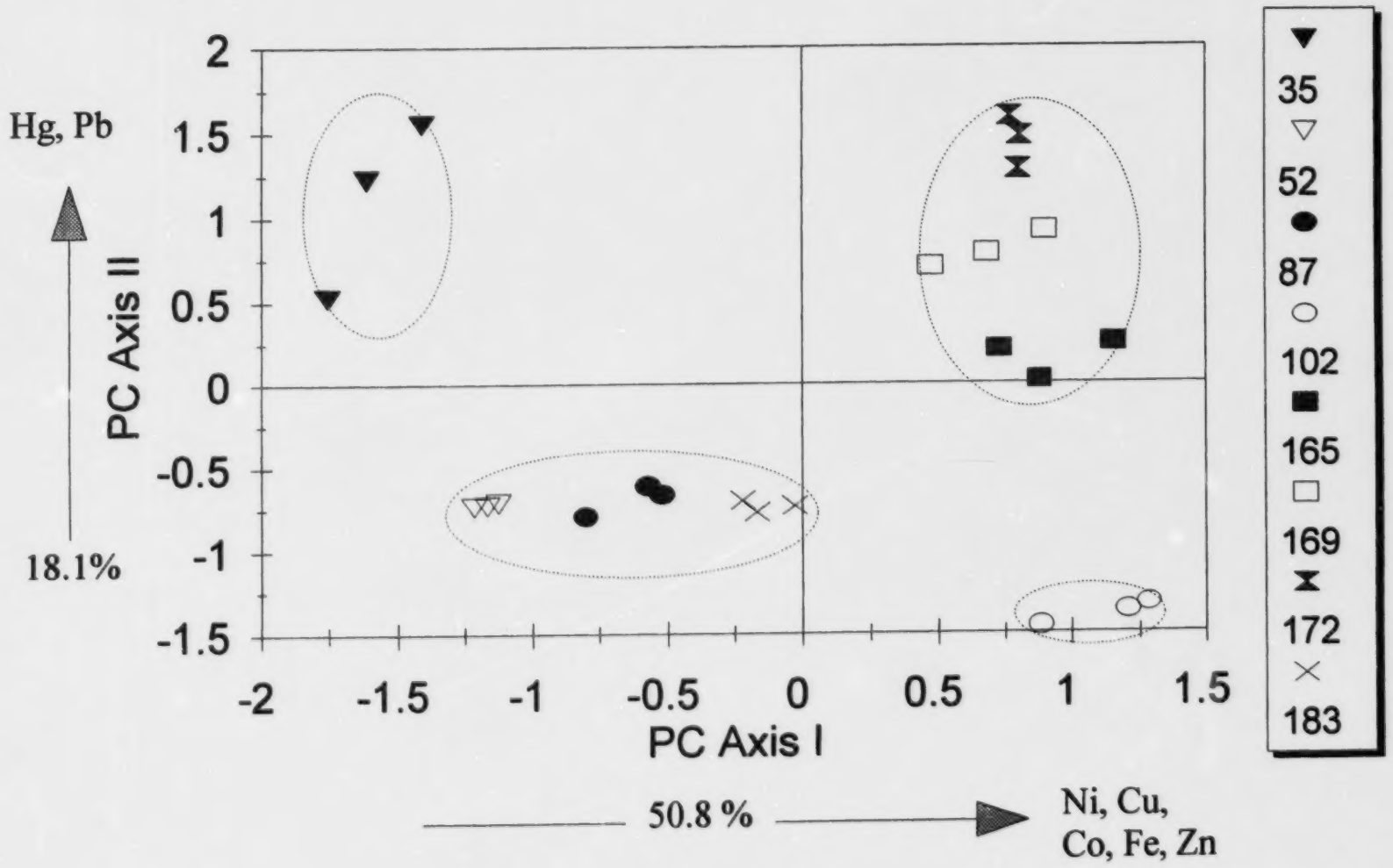

Figure 10. Summary plot of PCA results for metals concentrations in sediments.

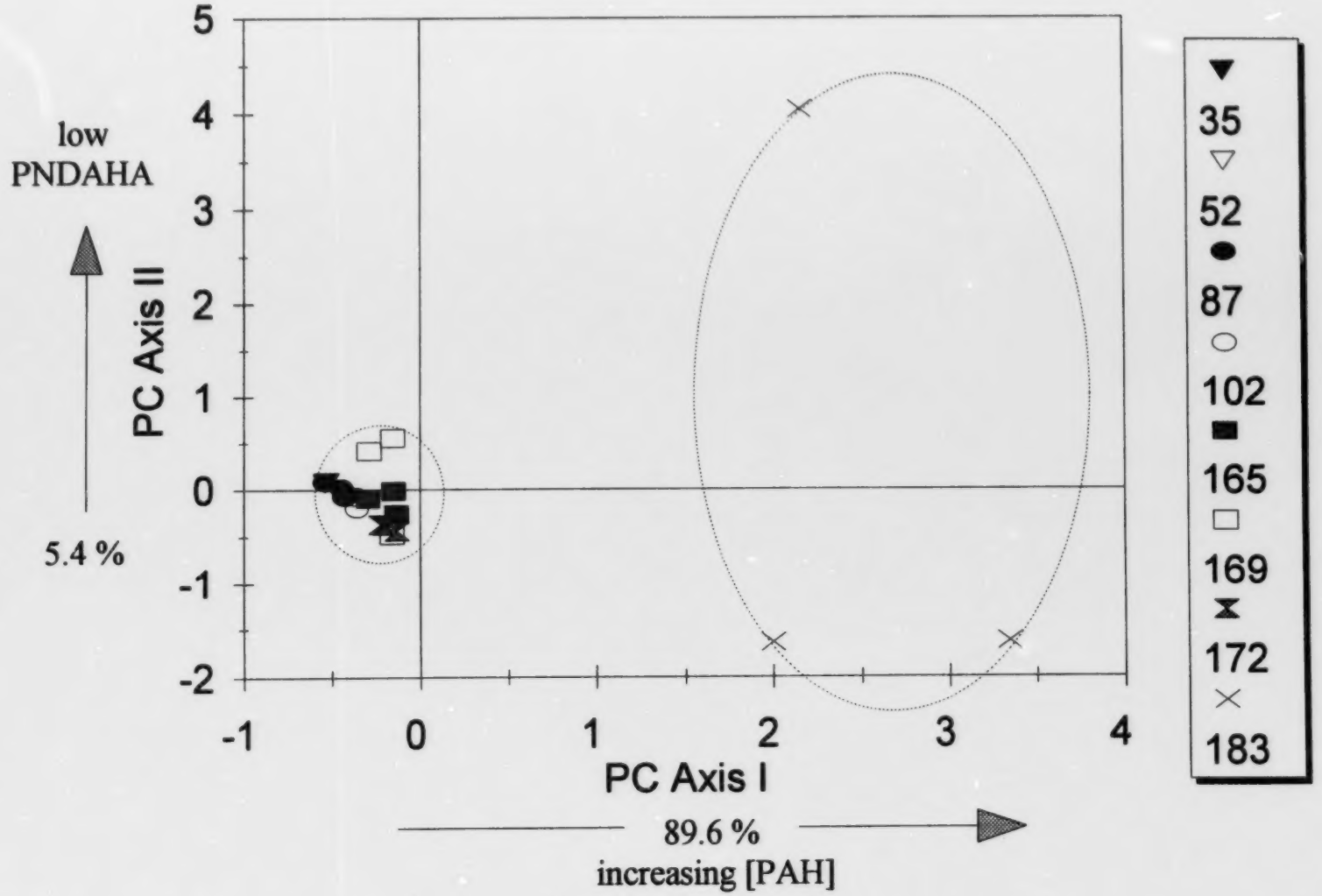

Figure 11. Summary plot of PCA results for polycyclic aromatic hydrocarbons concentrations in sediments.

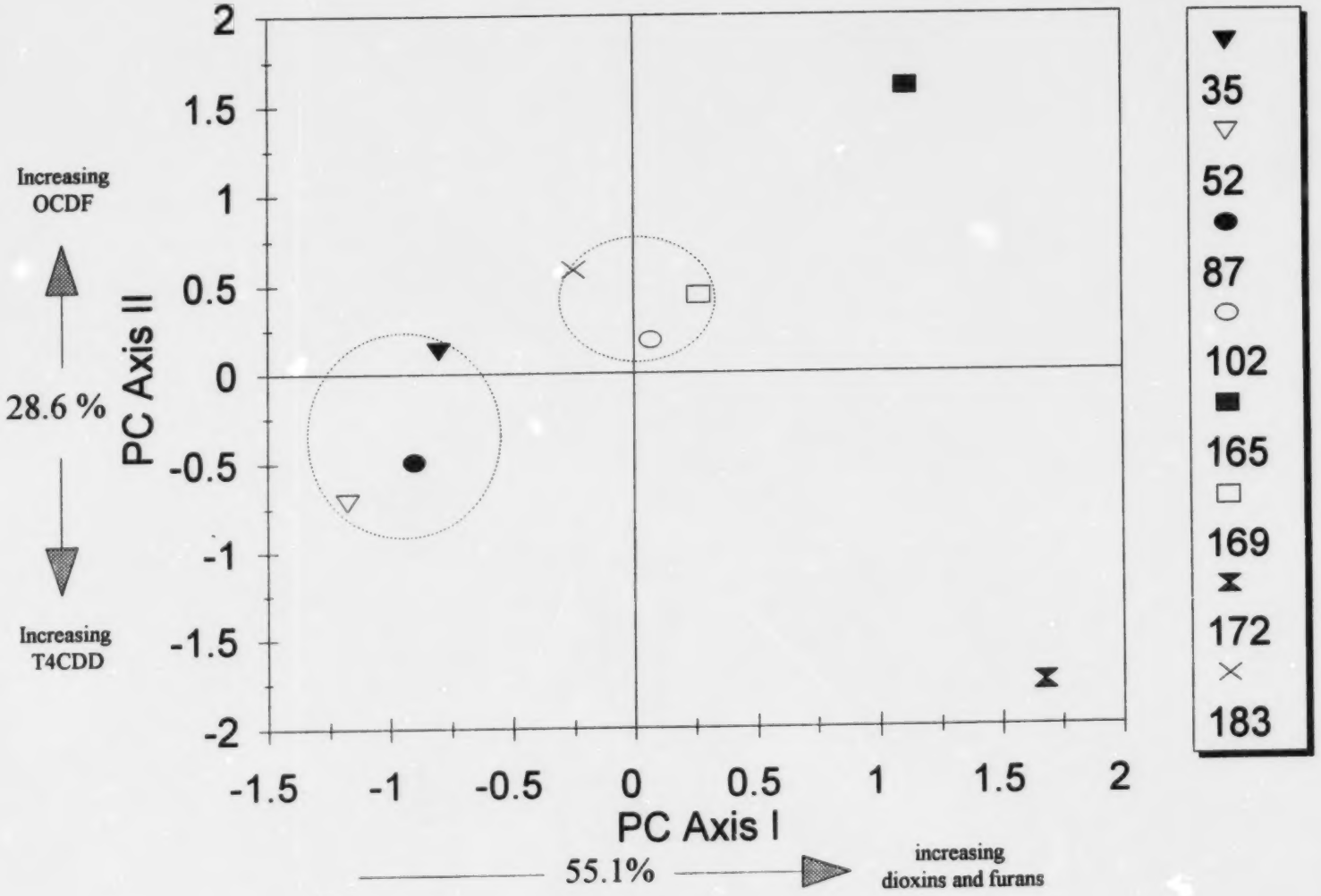

Figure 12. **Summary plot of PCA results for polychlorinated dioxins and furans concentrations in sediments.**

sand in the sample on the concentrations of heavy metals such as nickel, copper, cobalt, iron and zinc.

Concentrations of all PAH compounds in St. Marys River sediments were found to be highly correlated with each other ($r > 0.9$; see also Table C-10). PAHs were also correlated with total organic carbon (TOC) in sediments ($r > 0.9$). A PCA performed with PAHs and the with the first principal component accounted for almost 90 % of the variation in PAHs. The first PC axis differentiates Station 183 from all other stations due to the much higher PAH concentrations observed at that station (Fig. 11). The second PCA accounted for an additional 5 % of the variation, which was mainly due to a difference in PAH compounds measured in one of the three replicates from Station 165.

Only certain PCDD and PCDF compounds were detected in sediment samples, and then at low concentrations (Table 6). Most notably, heptachlorodibenzo-*p*-dioxins (H_7CDDs) and octachlorodibenzo-*p*-dioxin (O_8CDD) exhibited a spatial contamination pattern similar to that observed for PAHs. No official PSQGs have yet been published for PCDDs, PCDFs or their toxic isomers. However, the calculated Total 2,3,7,8-T_4CDD TEQ (normalized to 1 % TOC) slightly exceeded the draft Environment Canada guideline of 1.7 $ng.kg^{-1}$ (normalized to 1 % TOC) to prevent bioaccumulation by aquatic life (EC, 1994) at Station 35 in Tannery Bay. Principal components analysis on the five PCDD and five PCDF homolog groups identified three components, accounting for almost 95 % of the variation. The first component separated stations based on increasing PCDD/F concentrations in general. As indicated in Figure 12, Stations 35, 52 and 87 grouped together low on PC I due to the lower measured PCDD and PCDF concentrations at these stations. Of all eight locations sampled, Station 172 and 165 sediments exhibited the highest degree of PCDD and PCDF contamination. The subsequent principal components accounted for differences in the relative amounts of specific congeners present at each station.

4.3 Laboratory Sediment Bioassays

Results of *Hexagenia limbata* nymph and *Chironomus tentans* larvae acute and chronic toxicity tests with the St. Marys River sediments were highly correlated (Bedard & Petro, 1997). (Pearson correlation coefficients between these two test species were $r = 0.93$ for mortality and $r = 0.76$ for the growth response endpoint.) No significant detrimental effect on juvenile *Pimephales promelas* survival was detected in this study. This is in marked contrast to 1990, when fathead minnow mortality averaged 81.2 % at Station 183 (Pope & Kauss, 1995), and may reflect the somewhat lower contaminant concentrations at this station, or reduced bioavailabilty via the water column.

Table 8. **Summary of sediment bioassay results for sediments.** (Source: Bedard & Petro, 1997). Control sediments were obtained from Honey Harbour (Georgian Bay). Values are presented as means (± standard deviation). Mean body weight is on a wet weight basis. Mean values within a row sharing a common superscript letter(s) are not significantly different by Tukey's HSD test for % mortality ($p < 0.05$) and by planned comparisons using LSMeans for body weights ($p < 0.01$). Percent mortalities in bold are significantly different from Control and Station 52 by Dunnett's t-test ($p < 0.05$).

Test Organism	Endpoint	Control Honey Harbour	Station 52 Point aux Pins Bay	Station 35 Tannery Bay	Station 183 Algoma Slip	Station 165 Bellevue Marine Park	Station 172 Lake George Channel	Station 169 Lake George Channel	Station 87 Little Lake George	Station 102 Lake George
Hexagenia limbata	Morality, %	0 ± 0^{a}	0 ± 0^{a}	0 ± 0^{a}	**96.6** $\pm 6.0^{c}$	**23.3** $\pm 11.0^{b}$	10.0 ± 0.0^{ab}	**20.0** $\pm 0.0^{b}$	3.3 ± 6.0^{a}	0 ± 0^{a}
	Mean Weight, mg	8.0 ± 1.4^{bc}	10.2 ± 0.6^{bc}	24.8 ± 2.5^{a}	–	6.9 ± 2.0^{c}	6.8 ± 0.5^{c}	7.6 ± 0.4^{c}	11.6 ± 1.7^{b}	8.9 ± 0.5^{bc}
Chironomus tentans	Morality, %	4.4 ± 4.0^{ab}	2.2 ± 4.0^{a}	6.6 ± 7.0^{ab}	**95.5** $\pm 8.0^{c}$	**22.2** $\pm 10.0^{b}$	4.4 ± 4.0^{ab}	4.4 ± 4.0^{ab}	6.6 ± 7.0^{ab}	4.4 ± 8.0^{ab}
	Mean Weight, mg	8.0 ± 0.3^{b}	8.3 ± 0.6^{b}	10.8 ± 0.8^{a}	--	2.1 ± 0.4^{d}	4.8 ± 0.4^{dc}	3.7 ± 0.4^{c}	6.2 ± 1.4^{c}	6.1 ± 0.2^{cd}
Pimephales promelas	Morality, %	0 ± 0^{a}	0 ± 0^{a}	3.3 ± 6.0^{a}	3.3 ± 6.0^{a}	0 ± 0^{a}	3.3 ± 6.0^{a}	3.3 ± 6.0^{a}	0 ± 0^{a}	0 ± 0^{a}

Results of the bioassays are summarized in Table 8, indicating that Station 183 sediments were the most toxic, resulting in 95 % or higher mortality of *Hexagenia* and *Chironomus* test organisms. Sediment from Station 165, and 169 for *Hexagenia* only, exhibited a lower degree of toxicity (20 to 23 % mortality) than the Algoma Slip sediment, but this was still significantly greater than that observed with Control or Station 52 sediments (0 to 4 % mortality).

H. limbata and *C. tentans* growth, as determined by weight gain, was significantly greater ($p<0.01$) for Station 35 sediment than for Control and Station 52 sediments. This may be due to an hormesis effect or some other factor such as nutrient/food availability in Tannery Bay sediments. In contrast, *C. tentans* growth was significantly reduced by sediments from all stations in and downstream of Bellevue Marine Park (Stations 165, 172, 169, 87, 102). The growth endpoint in the *H. limbata* test did not follow a similar pattern (i.e., no effects on growth were observed with sediments from downstream stations with this test).

4.4 Integrated Analysis

Three discriminant functions were calculated to predict group membership of stations according to the four benthic community groupings based on a combination of original and derived environmental variables. The combined discriminant function separated station benthic invertebrate groups almost perfectly, suggesting some underlying relationship between benthic invertebrate community assemblages and environmental conditions (Fig. 13). Based on the observed correlations of predictor variables with discriminant functions (Table 9), it appears that PAHs and TOC concentrations are among the most important environmental variables affecting the benthic invertebrate communities at these stations. Station depth, sediment particle size, calcium and total phosphorus were also correlated with the first Discriminant Function (DF) axis and may be influencing or covarying factors on the benthic invertebrate communities. The second DF axis represented increasing nitrogen concentration and decreasing sediment density (i.e., increasing porosity). However, these findings must be interpreted with caution. The actual number of stations in the study was small compared with the large number of environmental variables examined. The benthic invertebrate data exhibited a large amount of variation among stations and the principal components defining the benthic groups accounted for less than half the observed variation. Spatial autocorrelation may produce apparent relationships even when no specific cause and effect can be ascertained.

Toxicity results for each station are compared with chemistry and benthic community results in an assessment matrix in Table 10, based on the approach of Chapman *et al.*, (1996).

Although chemistry and toxicity test results indicated Station 52 sediments to be of relatively

Table 9. **Pearson correlations between environmental variables and the first two discriminant functions for the benthic invertebrate communities**. The first two discriminant functions were significant using the Chi-square statistic (alpha < 0.001.)

Parameter	Discriminant Function	
	I	II
PAH PCA I	0.802	-0.409
TOC	0.759	-0.256
Calcium	0.631	-0.411
Particle size PCA I	0.495	-0.417
Chloride	0.466	0.265
Loss of Ignition	0.364	0.193
Density	0.339	-0.555
Particle Size PCA II	0.258	-0.128
Solvent Extractables	0.099	0.181
Total Kjeldahl Nitrogen	0.073	0.549
Ammonium (total reactive)	0.024	0.287
Metals PCA II	-0.161	0.017
Distance from CDN shore	-0.195	0.431
Metals PCA I	-0.262	0.068
Metals PCA III	-0.418	-0.152
Eh (Redox Potential)	-0.485	0.077
Moisture	-0.491	0.5
Water Depth	-0.554	-0.287
Total Phosphorus	-0.565	0.182

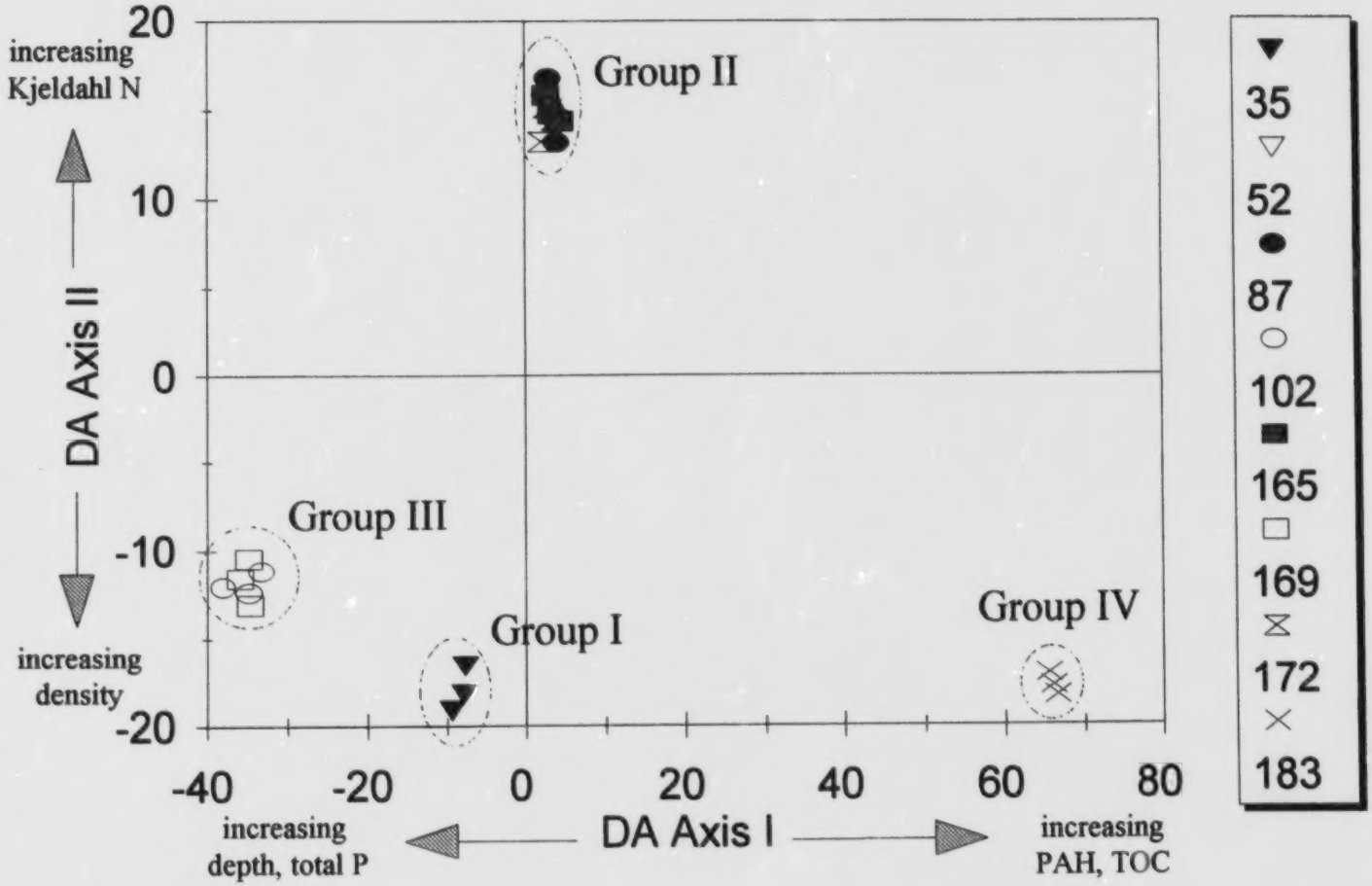

Figure 13. Sample cluster plots on first two discriminant functions.

good quality compared with the other stations, the benthic community at this station was relatively pauperate. This observation could be due to a number of factors including basic habitat conditions, and/or the presence of contaminants exceeding LELs, however no solid conclusions can be made at this time as to the possible cause of low benthic invertebrate numbers. The presence of at least some "sensitive" ephemeropteran taxa may indicate that pollution effects may be relatively unimportant in affecting benthic communities at this station.

Station 35 sediment contained very high concentrations of chromium which exceeded the PSQG-SEL by an order of magnitude. Lead, mercury, arsenic and cadmium levels also exceeded the respective PSQG-LELs. However, laboratory bioassay tests with *Hexagenia limbata*, *Chironomus tentans* and *Pimephales promelas* did not identify any toxicity. This suggests that these metals were not readily available to the organisms and/or did not exceed an actual toxic threshold in the tests. The bioassay test results correspond with the benthic invertebrate community results, since Station 35 had the richest and most abundant benthic fauna assemblage of all stations sampled in this study.

The high acute toxicity of Algoma Slip sediments, as indicated by the two invertebrate bioassays, would appear to explain the total absence of benthic invertebrates *in situ*. PAHs may be responsible for the toxicity of these sediments. Relative to other stations sampled, PAHs were significantly ($p < 0.05$) elevated at Station 183. Total PAHs were two orders of magnitude above the PSQG-LEL, but below the SEL guideline. Concentrations of other contaminants in Station 183 sediments were not appreciably different from those at Stations 102, 165, 169 and 172, where benthic invertebrates were still present in the sediments.

Station 102, 165, 169 and 172 sediments were all characterized by moderately elevated heavy metals and PAH concentrations, with numerous parameters exceeding the respective PSQG-LELs. Within this group of stations, laboratory bioassay test results indicated that Stations 165 and 169 were more toxic to the two benthic invertebrate species tested than were sediments from stations 172 or 102. All of these sediments resulted in chronic effects to *Chironomus tentans* ; however, only Station 165 and 169 sediments were acutely toxic. This association of stations based on toxicity test results does not correspond with the groups based on chemistry and benthic fauna results, in which Stations 102 and 169 consistently grouped together. Review of the sediment chemistry results did not indicate any obvious differences in contaminant profiles which might account for the differences in the observed toxicity among these stations.

Station 172, in the Lake George Channel, had the lowest diversity of the eight stations sampled. This was associated with a dominance by immature tubificid worms without hair setae (>80% relative abundance). Station 172 is located just downstream of the East End Sewage Treatment Plant which, results would suggest, may be responsible for impairment at this station. The benthic community at this station exhibited the classical response to severe organic enrichment

Table 10. Summary and interpretation of information provided by sediment chemistry, toxicity and benthic invertebrate data.

Station	Chemistry [1]		Toxicity [2]		Benthic Community Indicators	Conclusions
	>LEL	>SEL	Acute	Sublethal		
Station 52 Point aux Pins Bay	TKN, Cd,Cu, Fluor		- - -	- -	low richness and abundance; EPT taxa present	- low diversity/productivity of benthic community not due to toxicity
Station 35 Tannery Bay	TKN, As, Cd, Hg, Pb	Cr	- - -	- -	highest richness, diversity; EPT taxa present	- no evidence of toxicity associated with elevated metal levels in sediments
Station 183 Algoma Slip	TKN, TOC, As, Cd, Cr, Cu, Fe, Mn, Anth, BaA, BaP, BkF, Chry, DahA, Flan, Fluor, BghiP, IP, Phen, Pyr, TPAHs	TOC	+ + -	not applicable (no survivors)	no benthic invertebrates present	- severe degradation - elimination of benthic community - high toxicity in sediments associated with PAHs - interactions between PAHs and metals may affect toxicity
Station 165 Bellevue Marine Park	TKN, TP, TOC, As, Cd, Cr, Cu Hg, Mn, Ni, Pb Zn, Anth, BaA, BaP, BkF, Chry, DahA, Flan, Fluor, BghiP, IP, Phen, Pyr, TPAHs	Fe	+ - -	- +	asellid isopods > tubificid dominance; low diversity	- contamination by numerous metals/ PAHs - evidence suggests toxicity effecting benthic communities
Station 172 Lake George Channel	TKN, TP, TOC, As, Cd, Cr, Cu Hg, Ni, Pb, Zn, BaA, BaP, BkF, Chry, DahA, Flan, BghiP, IP, Phen, Pyr, TPAHs	Fe	- - -	- +	Extreme tubificid dominance; lowest diversity	- pollution effects on benthic community characteristic of organic enrichment/low DO - sublethal toxicity may be contributing factor to community impacts
Station 169 Lake George Channel	TKN, TP, TOC, As, Cd, Cr, Cu, Hg, Mn, Ni, Pb, Zn, BaA, BaP, BkF, Chry, DahA, Flan, BghiP, IP, Phen, Pyr, TPAHs	Fe	+ - -	- +	naidids > tubificid dominance; low diversity	- contamination by numerous metals/ PAHs - evidence suggests toxicity effecting benthic communities
Station 87 Little Lake George	TKN, TOC, As, Cu, DahA, BghiP, IP		- - -	- +	"meso"-tolerant community	-sublethal toxicity possible due to low level metals/PAHs - effect on benthic community indeterminant
Station 102 Lake George	TKN, TOC, As, Cd, Cr, Cu, Fe, Ni, Pb, Zn, BaA, BaP, BkF, Chry, DahA, BghiP, IP, TPAHs		- - -	- +	tubificid > chironomid dominance	- sublethal toxicity possibly due to metals/PAHs, organic enrichment probable - effect on benthic community indeterminant

NOTES: 1) see Table 6 for acronym equivalents.

2) Toxicity is presented as the combination of results ordered by test as *H. limbata; C. tentans; P. promelas* for acute toxicity and *H. limbata; C tentans* for sublethal toxicity. No sublethal endpoint was measured for the *P. promelas* test in this study. A "+" sign indicates that a positive toxic response (statistically different from control sediments) was observed for a test endpoint. A "-" sign indicates no toxic response. For example, at Station 102, no acute toxic responses were observed, however there was an effect on growth of *C. tentans* (acute = "- - -" ; sublethal = "- +") .

3) EPT = ephemeropterans.

and low dissolved oxygen often associated with sewage treatment plant effluent. The benthic community had a very low diversity, resulting from the very high abundance of a few pollution-tolerant forms. Stations 169, 165, 102 and 87 had more diverse benthic invertebrate community assemblages, comprised of many pollution-tolerant forms. However the relative dominance of naidid worms at Station 169 and 102, and of isopods at Stations 165 and 87, indicate an environment with reduced effects of organic pollution compared to Station 172.

Little Lake George sediments (Station 87) caused growth inhibition of *C. tentans*; however, it was not possible to discern the result of any such toxic effect on the resident benthic invertebrate community. Station 87 did, however, have a less rich fauna compared with Station 102. As with Station 102, Station 87 represents a lentic habitat, making direct comparison with the benthic fauna at riverine stations tenuous, due to potential habitat differences.

4.5 Sediment Quality and Benthic Community Trends

An attempt was made to determine if any long-term temporal trends are evident in the St. Marys River sediments. This was performed by comparing benthic invertebrate community (Table 10) and sediment quality data (Table 6) from the 1992 study with that from earlier Ministry surveys in 1983 (McKee *et al.*, 1984), 1985 (Burt *et al.*, 1988), 1987 (Pope, 1990), 1989 (Kauss, 1999; Kauss & Nettleton, 1999) and 1990 (Pope & Kauss, 1995). This proved difficult, since the eight stations sampled in 1992 were not always sampled in the earlier studies. Moreover, Station 35 was a completely new sampling location added for the 1992 survey. Finally, analytical capability was not readily available for some contaminants (e.g., PAHs) during the earlier studies.

Nevertheless, the data summarized in Table 11 shows that, for a number of the sediment contaminants, there has been a decrease in concentration over time; for others, the trend is variable, or perhaps increasing in more recent years. A decreasing trend was more evident at the Little Lake George and Lake George stations than at those located further upstream, perhaps due to the more depositional nature of the former. The most extensive temporal information is for Station 87 in Little Lake George, with data available for most contaminants from four years, dating back to 1985. Concentrations of a number of these contaminants are plotted in Figure 14, indicating decreases of 44 % or more between 1985 and 1992. For example, TKN, TP, arsenic, cadmium, chromium, copper, manganese, lead, nickel, zinc and solvent extractables decreased 51, 44, 52, 68, 58, 68, 53, 44, 36 and 54 %, respectively, over the seven year period. Total PAHs decreased by 55 % between 1987 and 1992. In fact, many contaminant concentrations were below their respective PSQG-LELs or OWDMDGs in 1992 sediment, and copper and solvent extractables were close (Fig. 14). This decrease was however, also evident in the sediment TOC content and to lesser extent, the proportion of silt and clay (Fig. 14). Statistical analysis of data

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Table 11. Comparison of St. Marys River sediment contaminant concentrations, 1985-1992.

Parameter	Units	Station 52			Station 183		Station 165		Station 172		Station 169		Station 87				Station 102	
		1987	1990	1992	1990	1992	1987	1992	1989	1992	1987	1992	1985	1987	1989	1992	1985	1992
Benthic Invertebrate Community Impairment	--	unim-paired	unim-paired	unim-paired to slight	severe	severe	severe	moderate	moderate	moderate	slight	moderate	moderate	--	--	moderate	moderate	moderate
Silt & Clay (<62 um diam.)	%	47.4	44.2	78.3	5.6	46.5	--	74.6	55.4	77.6	--	72	87.8	-78.2	68.6	72	96.3	99.3
Loss on Ignition	g kg^{-1}	**68**	21.2	130	58.5	**126**	97	104	56.8	107	108	113	97	**82**	58	43.7	64	60.3
Total Organic Carbon	"	28.0	9	59.3	75.5	**190**	93	76.7	41.2	63.9	84.8	69.3	56	52.5	34	22.3	35	30.5
Total Kjeldahl Nitrogen	"	1.1	--	2.30	--	1.76	2	2.36	2.1	3.1	1.8	1.96	3	3.45	1.8	1.46	1.8	1.47
Total Phosphorus	"	0.26	--	0.38	--	0.29	0.78	0.56	0.62	0.89	0.55	0.63	0.75	1.12	0.49	0.42	0.87	0.73
Arsenic	mg kg^{-1}	--	1.5	4.43	5.90	8.86	--	15.3	8.42	12	--	14.3	10.2	--	6.2	4.94	10.3	7.99
Cyanide	"	--	0.03	0.01<W	0.13	0.53	--	2.05	0.74	0.03	--	0.26	--	--	0.47	0.05	--	0.39
Cadmium	"	0.50	0.06	0.97<T	0.05	0.80<T	1.5	0.91<T	0.52<T	0.55<T	1.7	0.65<T	1.1	1.25	0.62	0.35<T	0.76	0.63<T
Chromium	"	9.60	14.5	18.6	23.5	28	**330**	73.7	38.4	81.3	45	57.7	61	54	38	25.7	53	47.3
Copper	"	12	8.7	26.0	21.2	27.8	69	55.2	26.6	57.6	55.5	54.4	69	70.5	36	22.2	59	41.6
Iron	"	5400	8066	7866	24333	20984	**115000**	**54929**	23513	**43970**	**51500**	**50236**	39000	**40000**	21000	16.619	38000	31319
Lead	"	24.0	3.20	17.7	16.0	27.6	120	61.9	39.7	87.3	62.5	71.6	54	50	36	30.3	49	48.9
Magnesium	"	970	2350	2200	3267	4094	4400	3897	3887	2964	2850	3060	--	5600	3800	2964	--	6931
Manganese	"	55.0	95.8	100	618	766	790	566	319	373	565	556	480	460	280	226	490	409
Mercury	"	--	0.02	0.04<T	0.02<T	0.04<T	--	0.15	0.25	0.41	--	0.20	0.19	--	0.01<W	0.07	0.16	0.10
Nickel	"	4.2	9.10	8.90	13.5	13	45	29	13.3	22.3	16.5	27	23	21	18	14.6	25	29.3
Zinc	"	24.0	21.2	46.3	71.2	107	280	190	140	243	200	223	220	205	140	101	210	169
Solvent Extractables	"	1260	587	**2704**	**2574**	**5379**	**7140**	**7865**	**3814**	**6126**	**13250**	**7114**	**7665**	**10063**	**2340**	**2159**	**3228**	**2892**
Total of 16 PAHs	"	0.62<T	0.07<W	0.97	686	292	49.4	14.6	3.51	10.8	18.8	13.9	--	5.43	1.56	2.47	--	4.75
No. of Samples Analyzed		2	6	3	1	3	1	3	1	3	1	3	1	1	1	3	1	3
Data Source		c	b	a	b	a	c	a	e	a	d, c	a	f	d, c	e	a	f	a

NOTES: Underlined value in shaded cell exceeds Provincial Sediment Quality Lowest Effect Level Guideline (PSQG-LEL) or Open Water Dredged Material Disposal Guideline (OWDMDG) - see Table 6
Value in **bold** type exceeds the Provincial Sediment Quality Severe Effect Level Guideline (PSQG-SEL) - see Table 6
"--" = no data available or not applicable
"<" = estimated value
"<W" suffix = no measurable response (zero), less than reported value
"<T" suffix = a measurable trace amount, interpret with caution

Data Sources
a - this study, b - Pope & Kauss (1995), c - OME, unpubl. data, d - Pope (1990), e - Kauss & Nettleton (1990), f - Burt *et al.* (1988)

Table 11. Comparison of St. Marys River sediment contaminant concentrations, 1985-1992.

Parameter	Units	Station 52			Station 183		Station 165		Station 172		Station 169		Station 87				Station 102	
		1987	1990	1992	1990	1992	1987	1992	1989	1992	1987	1992	1985	1987	1989	1992	1985	1992
Benthic Invertebrate Community Impairment	--	unim-paired	unim-paired	unim-paired to slight	severe	severe	severe	moderate	moderate	moderate	slight	moderate	moderate	--	--	moderate	moderate	moderate
Silt & Clay (<62 um diam.)	%	47.4	44.2	78.3	5.6	46.5	--	74.6	55.4	77.6	--	72	87.8	-78.2	68.6	72	96.3	99.3
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Total Organic Carbon	"	28.0	9	59.3	25.5	**190**	93	76.7	41.2	63.9	84.8	69.3	56	52.5	34	22.3	35	30.5
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Cyanide	"	--	0.03	0.01<W	0.13	0.53	--	2.05	0.74	0.03	--	0.26	--	--	0.47	0.05	--	0.39
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Magnesium	"	970	2350	2200	3267	4094	4400	3897	3887	2964	2850	3060	--	5600	3800	2964	--	6931
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Mercury	"	--	0.02	0.04<T	0.02<T	0.04<T	--	0.15	0.25	0.41	--	0.20	0.19	--	0.01<W	0.07	0.16	0.10
Nickel	"	4.2	9.10	8.90	13.5	13	45	29	13.3	22.3	16.5	27	23	21	18	14.6	25	29.3
Zinc	"	24.0	21.2	46.3	71.2	107	280	190	140	243	200	223	220	205	140	101	210	169
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Total of 16 PAHs	"	0.62<T	0.07<W	0.97	686	292	49.4	14.6	3.51	10.8	18.8	13.9	--	5.43	1.56	2.47	--	4.75
No. of Samples Analyzed:		2	6	3	1	3	1	3	1	3	1	3	1	1	1	3	1	3
Data Source:		c	b	a	b	a	c	a	e	a	d, c	a	f	d, c	e	a	f	a

NOTES: Underlined value in shaded cell exceeds Provincial Sediment Quality Lowest Effect Level Guideline (PSQG-LEL) or Open Water Dredged Material Disposal Guideline (OWDMDG) - see Table 6.
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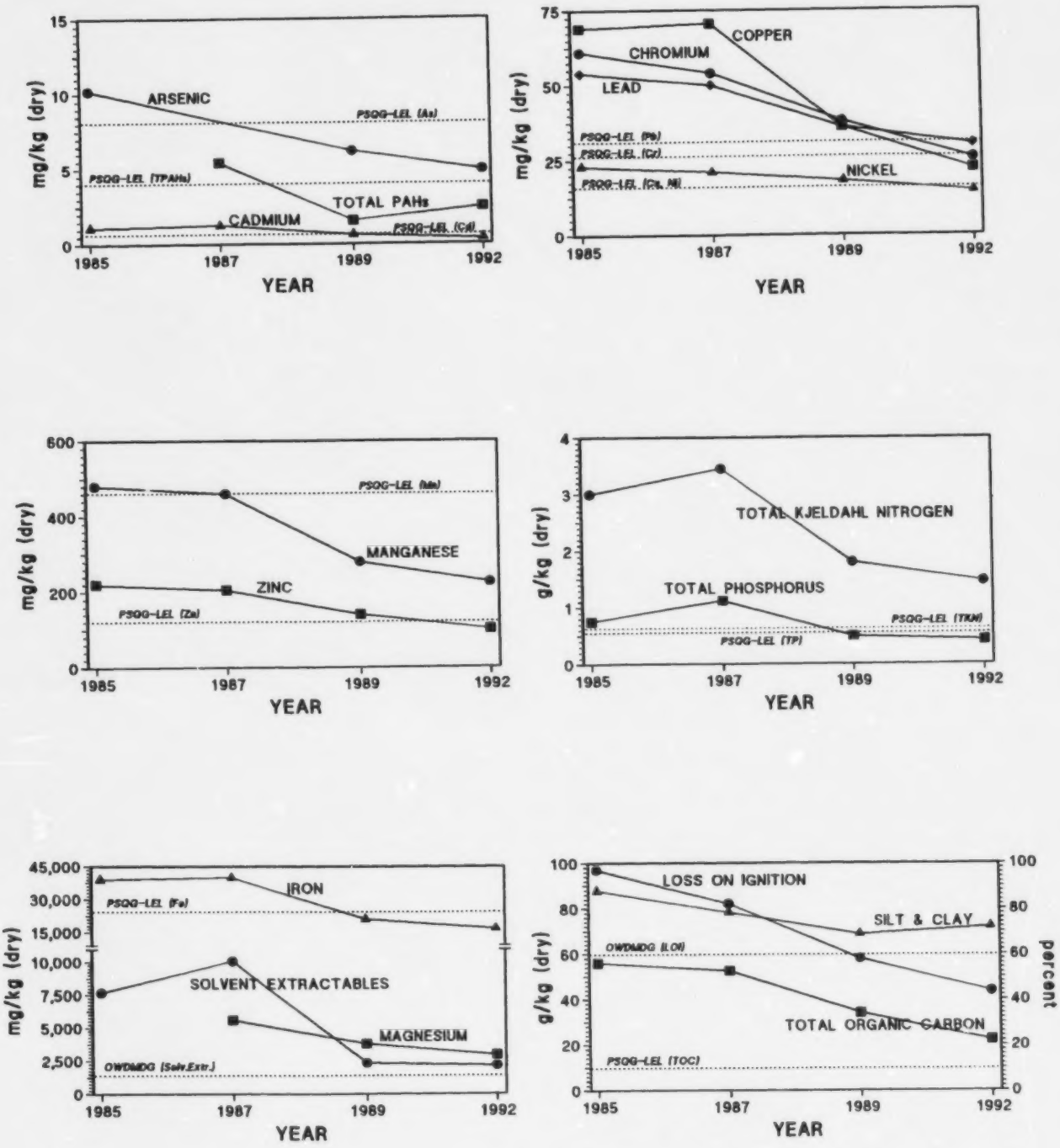

Figure 14. Sediment quality trends at Station 87 in Little Lake George.

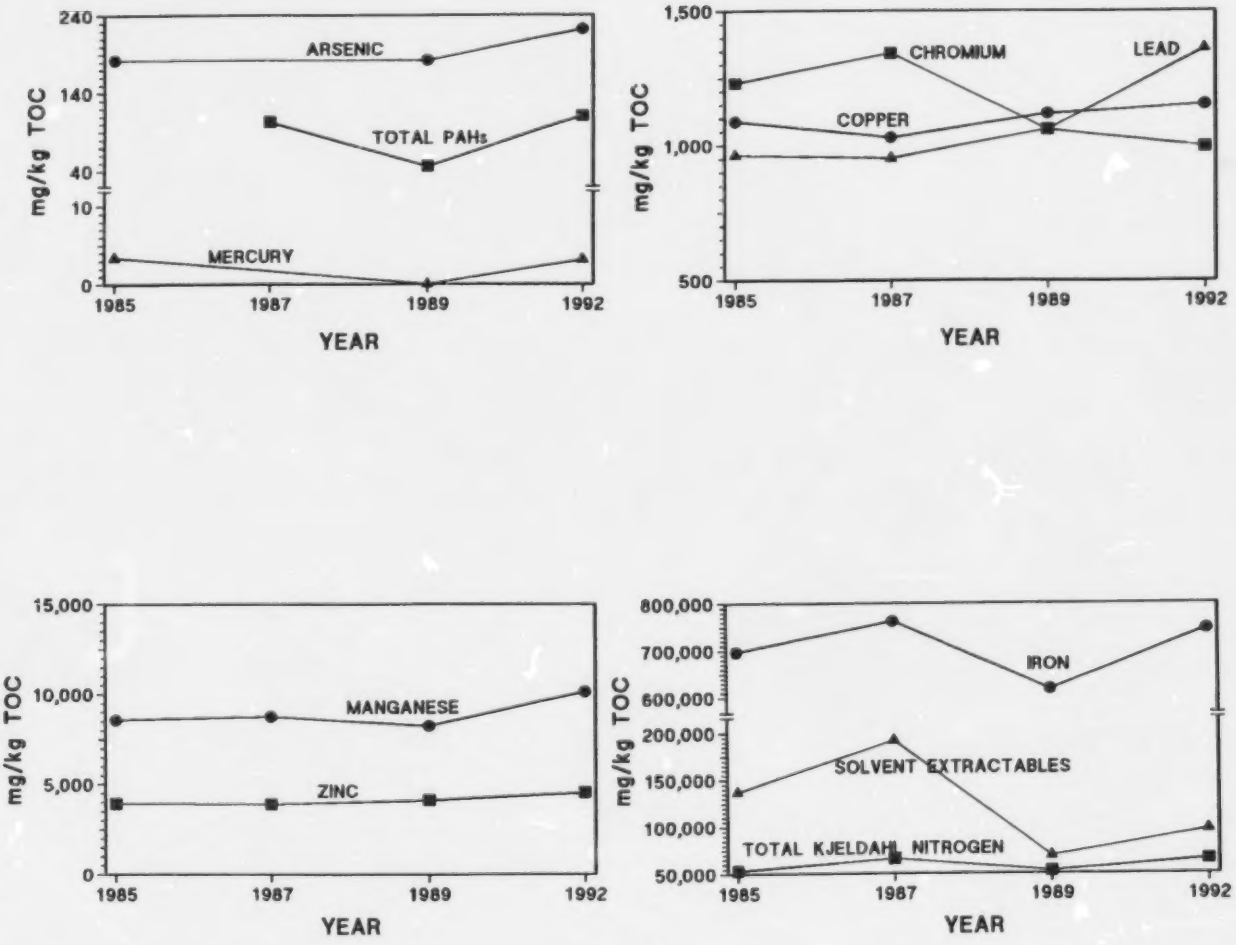

Figure 15. **Sediment quality trends (TOC-normalized) at Station 87 in Little Lake George.**

from Stations 165, 172, 169 and 87 (those most relevant to this section of the river) indicated significant positive correlations (Pearson Product-Moment; $p < 0.05$, see Table C-11) between TOC concentrations and those of TKN, solvent extractables, arsenic, chromium, copper, iron, lead, mercury, manganese, selenium, zinc and Total PAHs (Appendix C). Plots of sediment contaminant concentrations normalized to TOC indicate a relatively unchanging (e.g., Total Kjeldahl nitrogen, copper, zinc), an increasing (e.g., arsenic, lead, manganese), or variable (e.g., iron, solvent extractables, Total PAHs) trend over time (Fig. 15).

Benthic community status appears to have changed little, i.e., "moderately impaired" (Table 11), although there is only information for 1985 and 1992.

The specific reasons for the increases in some contaminant concentrations over time at certain stations (e.g., chromium, iron and manganese at Station 52) are unclear, but may be related to local spatial heterogeneity and/or the temporal variability (i.e., transient nature due to movement of sediments in the river) as a result of physical factors (e.g., short- or long-term changes in the outflow from Lake Superior and/or flow patterns in the river, wave action, storms, vessel-induced turbulence). Except for sediments in the deepest areas of some water bodies (e.g., Lakes Superior and Ontario), those in the connecting rivers, riverine lakes and shallower areas of lakes will eventually be resuspended and moved downstream (Allan, 1986; Carter & Hites, 1992; Hawley *et al.*, 1996; McCorquodale & Tomczak, 1998).

5.0 CONCLUSIONS AND RECOMMENDATIONS

Eight stations in the upper St. Marys River, spanning a distance of about 40 km., were sampled in 1992. Of these stations, the sediments at the Algoma Slip station were completely devoid of benthic invertebrates and were also acutely toxic in laboratory sediment bioassays. Elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) were found in these sediments and appear to be linked to the observed toxic impacts. Statistical analysis (i.e., ordination and cluster) of the benthic invertebrate data identified three groups among the seven remaining stations. These were identified as: Group I (Tannery Bay); Group II (Lake George Channel and Lake George) and Group III (Points aux Pins Bay, Little Lake George, Bellevue Marine Park and Lake George Channel).

Contaminants found at elevated concentrations in the St Marys River sediment samples included arsenic, cyanide, heavy metals, solvent extractables (oils and greases) and numerous PAHs. No polychlorinated biphenyls (PCBs), chlorinated phenols, chlorinated benzenes, organochlorine pesticides, phenoxyacid herbicides or triazine herbicides were found in river sediments above their respective analytical minimum reporting limits. Significant correlations were found among sediment chemistry parameters within specific contaminant groups for metals, PAHs and polychlorinated dioxins and furans. Principal components analysis was used to reduce the multivariate data sets to one or two principal components for these parameter groups and for sediment particle size data. A strong positive correlation was observed between total organic carbon (TOC) and PAH concentrations in the sediments.

Discriminant function analysis using principal components derived from environmental variables (as outlined above), discriminated among station groups derived from the benthic invertebrate community data. Based on this analysis, PAHs, TOC and station depth appeared to be important factors affecting benthic communities. Particle size, total phosphorus, total Kjeldahl nitrogen and calcium were also identified as environmental variables possibly influencing the benthic communities. However, this conclusion must be interpreted cautiously in light of the inherent limitations of the data. Spatial autocorrelation may be in part responsible for the observed relationships.

Laboratory sediment bioassays with *Hexagenia limbata* nymphs and *Chironomus tentans* larvae indicated toxicity in all sediments except those from the two stations upstream of St. Marys Falls and Sault Ste. Marie point source discharges (i.e., Point aux Pins Bay and Tannery Bay). Bioassays using juvenile fathead minnows (*Pimephales promelas*) did not detect toxicity in any sediments. In general, the sediment toxicity results were in agreement with the benthic invertebrate community and chemistry results. There were however, several apparent exceptions, including:

- Concentrations of chromium exceeded the Provincial Aquatic Sediment Quality Severe Effect Level (SEL) guideline in Tannery Bay sediments, but no toxicity or negative effects on the benthic invertebrate community were apparent; and

- Sediments from stations in Bellevue Marine Park and Lake George Channel were more closely associated in terms of toxicity test results than was predicted by benthic invertebrate community or sediment chemistry information.

- Concentrations of copper, cadmium and fluorene exceeding Provincial Aquatic Sediment Quality Lowest Effect Level (LEL) guidelines in Point aux Pins Bay were apparently not toxic to the benthic taxa, as indicated by the sediment bioassay results. Sediment toxicity would therefore not appear to be an important factor contributing to the relatively low richness and productivity of the benthic community at that station.

Good evidence exists to suggest that toxicity from contaminants in sediments is adversely affecting benthic communities at Bellevue Marine Park and in Lake George Channel. At the former, where the highest degree of toxicity was observed, asellid isopods dominated the benthic community, which may indicate a low relative sensitivity of this taxon to the effect of pollutants. Based on comparisons of contaminant levels among sites, a specific contaminant and/or environmental conditions could not be identified which could be related to the high degree of toxicity observed for Bellevue Marine Park sediment.

Sublethal toxicity was observed in bioassays with the sediments from Little Lake George and Lake George, and these stations may be slightly impacted by such effects, either alone or in combination with organic enrichment. Most notably, the benthic community from Lake George was indicative of effects associated with organic enrichment.

Benthic communities at a station in Lake George Channel just downstream of the East End sewage treatment plant outfall exhibited characteristics of a classic organic enrichment model, resulting in very low diversity and high abundance of a few pollution-tolerant species.

To determine if any long-term temporal trends exist in the St. Marys River sediments, benthic invertebrate community and sediment quality data were compared with that from earlier Ministry surveys in 1983, 1985, 1987, 1989 and 1990. Benthic invertebrate community status appears to have changed little over the years. For a number of the sediment contaminants, there was a decrease in concentration over time; for others, the trend was variable, or perhaps even increasing in more recent years. A decreasing trend was more evident at the Little Lake George and Lake George stations than at those located further upstream, perhaps due to their more depositional nature. The most extensive temporal information was for Station 87 in Little Lake George, with data available for most contaminants from four years, dating back to 1985.

Concentrations of a number of these contaminants (TKN, TP, arsenic, cadmium, chromium, copper, manganese, lead, nickel, zinc and solvent extractables) indicated decreases of 40 % or more between 1985 and 1992. Total PAHs decreased by 55 % between 1987 and 1992. This decrease was however, also evident in the sediment TOC content and to lesser extent, the proportion of silt and clay. Statistical analysis of data from Stations 165, 172, 169 and 87 indicated significant positive correlations between TOC concentrations and those of TKN, solvent extractables, arsenic, chromium, copper, iron, lead, mercury, manganese, selenium, zinc and Total PAHs. Plots of sediment contaminant concentrations normalized to TOC indicated a relatively unchanging (e.g., total Kjeldahl nitrogen, copper, zinc), an increasing (e.g., arsenic, lead, manganese), or variable (e.g., iron, solvent extractables, Total PAHs) trend over time. Reasons for the increases in some contaminant concentrations over time at certain stations (e.g., chromium, iron and manganese at Station 52) are unknown, but may be related to spatial heterogeneity and/or the temporal variability as a result of physical factors.

<u>Recommendation:</u> Due to the spatial variability of sediments in the river and their dynamic nature, several stations should be sampled within a sub-area (e.g., Lake George Channel) to obtain a more representative picture of sediment quality and benthic community status. These should be re-sampled periodically (e.g., every five years, or after completion of major upstream source remediation) to obtain trend information. In addition, the collection, chemical analysis and radiodating of discrete sections of sediment cores from a "depositional" area of the river (e.g., Lake George) will provide a good historical perspective of sediment quality and upstream contaminants loadings.

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APPENDIX A

Station Locations and Descriptions

Table A-1. St. Marys River 1992 sampling station locations and descriptions.

Station Number	Description	metres from nearest shore	mean water depth, metres	Latitude (N)	Longitude (W)	Benthic Invertebrate Community Impairment
52	in Point aux Pins Bay (ON)	480	4.6	46°29'49"	84°28'06"	unimpaired
35	in Tannery Bay, adjacent to old North Western Leather tannery dump site (MI)	50	0.5	46°29'28"	84°23'45"	unknown
183	in upper (west) portion of Algoma Slip, near Bennett Creek discharge (ON)	25	2.6	46°31'16"	84°22'48"	severe
165	in Belleview Marine Park (ON)	500	2.5	46°29'55"	84°18'15"	severe
172	in Lake George Channel, 50 m downstreanm of East End WWTP discharge (ON)	150	1.7	46°30'31"	84°15'12"	moderate
169	in Lake George Channel, 1190 m downstream of Partridge Point (ON)	180	6.9	46°29'44"	84°13'15"	slight
87	in Little Lake George (ON)	870	2.2	46°32'26"	84°11'36"	moderate
102	in upper-middle portion of Lake George (MI)	1275	15.2	46°29'29"	84°07'44"	moderate

NOTES: "ON" = Ontario
"MI" = Michigan
coordinates and geographic references as per NOAA chart 14883, NAD1983 (WGS1984) projection; distances from shore determined by radar.

APPENDIX B

Benthic Invertebrate Data

Table B-1. Mean density (number. m^{-2}) of benthic organisms at each station in the St. Marys River, 1992. The mean (n=3), standard deviation (S.D.) and coefficient of variation (C.V.) of total abundance and richness are also given.

	Station							
TAXON	52	35	183	165	172	169	87	102
Mollusca								
Gastropoda								
Valvatidae								
Valvata sincera	0	53	0	477	0	0	0	7
Viviparidae								
Campeloma decisum	0	0	0	7	0	0	0	0
Pelecypoda								
Sphaeridae								
Pisidium sp.	0	794	0	51	0	84	0	7
Sphaerium sp	0	7	0	0	0	0	0	7
Sphaerium heringianus	0	0	0	0	0	0	0	27
Nematoda	152	1077	0	1097	1787	253	1671	124
Annelida								
Hirudinea								
Erpobdellidae								
Mooreobdella fervida	0	20	0	0	0	0	0	0
Glossophoniidae								
Helobdella stagnalis	0	206	0	0	0	0	0	0
Helobdella fusca	0	27	0	0	0	0	0	0
Alboglossiphonia heteroclita	0	512	0	0	0	0	0	0
Oligochaeta								
Enchytraeidae	0	2149	0	0	0	0	0	0
Naididae								
Slavina appendiculata	0	0	0	0	0	2934	107	62
Nais variabilis	0	53	0	213	84	443	213	7
Pristinella osborni	0	0	0	0	84	0	0	0
Vejdovskyella intermedia	0	0	0	0	0	1288	0	38
Ophidonais serpentina	0	0	0	0	0	63	0	0
Chaetogaster diaphanous	0	0	0	0	0	0	0	18
Lumbriculidae								
Stylodrilus heringianus	0	346	0	498	0	0	0	0
Tubificidae								
immature without hair setae	51	20	0	1778	12076	1731	583	180
immature with hair setae	0	1481	0	0	0	0	0	0
Spirosperma ferox	152	0	0	640	169	697	107	20
Potamothrix vejdovskyi	0	1409	0	0	0	1288	0	193
Limnodrilus hoffmeisteri	0	0	0	213	378	0	107	0
Aulodrilus pluriseta	0	0	0	0	0	0	0	109
Sparganophilia								
Sparganophilus einseni	0	20	0	7	0	0	0	0
Polychaeta								
Sabellidae								
Manayunkia speciosa	0	0	0	0	0	0	0	31
Arthropoda								
Ephemeroptera								
Tricorythidae								
Trichorythodes sp.	0	20	0	7	0	0	0	0

Table B-1 continued.

TAXON	Station 52	35	183	165	172	169	87	102
Caenidae								
Caenis sp	0	53	0	0	0	0	0	0
Hexageniidae								
Hexagenia limbata	20	0	0	0	0	0	0	0
Trichoptera								
Polycentropodidae								
Phylocentopus sp	51	0	0	0	0	0	0	0
Diptera								
Empididae								
Chelifera sp	0	186	0	0	0	0	0	18
Cerratopogonidae	0	60	0	0	0	0	0	0
Chironomidae								
Procladius sp	51	0	0	264	0	296	284	98
Apsectrotanypus sp	0	0	0	0	0	0	0	0
Rheotanytarsus sp	0	253	0	0	0	0	0	0
Chironomus sp	0	0	0	51	0	401	85	24
Glyptotendipes sp	0	107	0	0	0	0	171	0
Micropsectra sp	203	186	0	0	0	0	0	38
Pagastiella sp	101	0	0	0	0	0	0	0
Eukiefferiella sp	51	167	0	213	0	0	0	182
Cladopelma sp	0	0	0	0	0	84	0	0
Stictochironomus sp	0	922	0	0	0	0	0	0
Xenochironomus sp	0	51	0	0	0	0	0	0
Cryptochironomus sp	0	104	0	0	0	0	0	0
Cladotanytarsus sp	0	267	0	0	0	0	0	0
Phaenopsectra sp	0	1067	0	0	0	0	0	0
Tanytarsus sp	0	7	0	0	0	0	0	0
Potthastia sp	0	13	0	0	0	0	0	0
Pupae	0	51	0	0	0	148	0	0
Crustacea								
Decapoda								
Cambaridae								
Orconectes limosus	0	0	0	7	0	0	7	0
Amphipoda								
Talitridae								
Hyalella sp	0	439	0	0	0	0	0	0
Gammaridae								
Gammarus lacustris	51	0	0	0	0	0	0	0
Isopoda								
Asellidae								
Caecidotea sp	152	0	0	4791	0	0	562	0
Lirceus sp	0	0	0	0	0	0	427	0
Copepoda	0	0	0	0	0	0	0	60
Tardigrada	0	0	0	0	0	0	107	0
MEAN TOTAL ABUNDANCE	1033	12262	0	10306	14578	9711	4430	1249
S.D.	226	4351	-	6188	10969	1527	2509	284
C.V. %	21.9	35.5	-	60.0	75.2	15.7	56.6	22.8
MEAN RICHESS (number of taxa)	6	20.7	0	7.7	3.7	9.7	6	13.3
S.D.	1	5	-	2.1	1.5	1.2	2	2.5
C.V. %	16.7	24.2	-	27.3	40.5	12.4	33.3	18.8

Table B-2. Density (number.m^{-2}) of benthic organisms in individual replicates.

TAXON	Station 35			Station Mean	Standard Deviation	Relative Abundance
	1	2	3			
Mollusca						
Gastropoda						
Valvatidae						
Valvata sincera	160	0	0	53	92	0.43
Viviparidae						
Campeloma decisum	0	0	0	0	0	0.00
Pelecypoda						
Sphaeridae						
Pisidium sp.	0	608	1773	794	901	6.47
Sphaerium sp	0	20	0	7	12	0.05
Sphaerium heringianus	0	0	0	0	0	0.00
Nematoda	2400	324	507	1077	1149	8.78
Annelida						
Hirudinea						
Erpobdellidae						
Mooreobdella fervida	20	0	40	20	20	0.16
Glossophoniidae						
Helobdella stagnalis	60	304	253	206	129	1.68
Helobdella fusca	20	60	0	27	31	0.22
Alboglossiphonia heteroclita	320	456	760	512	225	4.18
Oligochaeta						
Enchytraeidae	4320	608	1520	2149	1934	17.53
Naididae						
Slavina appendiculata	0	0	0	0	0	0.00
Nais variabilis	160	0	0	53	92	0.43
Pristinella osborni	0	0	0	0	0	0.00
Vejdovskyella intermedia	0	0	0	0	0	0.00
Ophidonais serpentina	0	0	0	0	0	0.00
Chaetogaster diaphanous	0	0	0	0	0	0.00
Lumbriculidae						
Stylodrilus heringianus	480	304	253	346	119	2.82
Tubificidae						
immature without hair setae	0	60	0	20	35	0.16
immature with hair setae	2720	456	1267	1481	1147	12.08
Spirosperma ferox	0	0	0	0	0	0.00
Potamothrix vejdovskyi	1440	760	2027	1409	634	11.49
Limnodrilus hoffmeisteri	0	0	0	0	0	0.00
Aulodrilus pluriseta	0	0	0	0	0	0.00
Sparganophilia						
Sparganophilus eiseni	20	20	20	20	0	0.16
Polychaeta						
Sabellidae						
Manayunkia speciosa	0	0	0	0	0	0.00
Arthropoda						
Ephemeroptera						
Tricorythidae						
Trichorythodes sp.	320	152	0	157	160	1.28
Caenidae						
Caenis sp.	160	0	0	53	92	0.43
Hexagenidae						
Hexagenia limbata	0	0	0	0	0	0.00

Table B-2 continued

TAXON	Station 35			Station Mean	Standard Deviation	Relative Abundance
	1	2	3			
Trichoptera						
Polycentropodidae						
Phylocentopus sp.	0	0	0	0	0	0.00
Diptera						
Empididae						
Chelifera sp.	0	304	253	186	163	1.52
Cerratopogonidae	160	20	0	60	87	0.49
Chironomidae						
Procladius sp.	0	0	0	0	0	0.00
Apsectrotanypus sp.	0	0	0	0	0	0.00
Rheotanytarsus sp.	0	760	0	253	439	2.07
Chironomus sp.	0	0	0	0	0	0.00
Glyptotendipes sp.	320	0	0	107	185	0.87
Micropsectra sp.	0	304	253	186	163	1.52
Pagastiella sp.	0	0	0	0	0	0.00
Eukiefferiella sp.	480	20	0	167	272	1.36
Cladopelma sp.	0	0	0	0	0	0.00
Stictochironomus sp.	1600	912	253	922	673	7.52
Xenochironomus sp.	0	152	0	51	88	0.41
Cryptochironomus sp.	160	152	0	104	90	0.85
Cladotanytarsus sp.	0	40	760	267	428	2.17
Phaenopsectra sp.	160	0	3040	1067	1711	8.70
Tanytarsus sp.	0	20	0	7	12	0.05
Potthastia sp.	0	40	0	13	23	0.11
Pupae	0	152	0	51	88	0.41
Crustacea						
Decapoda						
Cambaridae						
Orconectes limosus	0	0	0	0	0	0.00
Amphipoda						
Talitridae						
Hyalella sp.	0	304	1013	439	520	3.58
Gammaridae						
Gammarus lacustris	0	0	0	0	0	0.00
Isopoda						
Asellidae						
Caecidotea sp.	0	0	0	0	0	0.00
Lirceus sp.	0	0	0	0	0	0.00
Copepoda	0	0	0	0	0	0.00
Harpacticoda						
Tardigrada	0	0	0	0	0	0.00
TOTALS	15480	7312	13993	12262		100

Table B-2. continued.

TAXON	Station 52			Station Mean	Standard Deviation	Relative Abundance
	1	2	3			
Mollusca						
Gastropoda						
Valvatidae						
Valvata sincera	0	0	0	0	0	0.00
Viviparidae						
Campeloma decisum	0	0	0	0	0	0.00
Pelecypoda						
Sphaeridae						
Pisidium sp.	0	0	0	0	0	0.00
Sphaerium sp	0	0	0	0	0	0.00
Sphaerium heringianus	0	0	0	0	0	0.00
Nematoda	0	304	152	152	152	14.71
Annelida						
Hirudinea						
Erpobdellidae						
Mooreobdella fervida	0	0	0	0	0	0.00
Glossophoniidae						
Helobdella stagnalis	0	0	0	0	0	0.00
Helobdella fusca	0	0	0	0	0	0.00
Alboglossiphonia heteroclita	0	0	0	0	0	0.00
Oligochaeta						
Enchytraeidae	0	0	0	0	0	0.00
Naididae						
Slavina appendiculata	0	0	0	0	0	0.00
Nais variabilis	0	0	0	0	0	0.00
Pristinella osborni	0	0	0	0	0	0.00
Vejdovskyella intermedia	0	0	0	0	0	0.00
Ophidonais serpentina	0	0	0	0	0	0.00
Chaetogaster diaphanous	0	0	0	0	0	0.00
Lumbriculidae						
Stylodrilus heringianus	0	0	0	0	0	0.00
Tubificidae						
immature without hair setae	152	0	0	51	88	4.90
immature with hair setae	0	0	0	0	0	0.00
Spirosperma ferox	304	0	152	152	152	14.71
Potamothrix vejdovskyi	0	0	0	0	0	0.00
Limnodrilus hoffmeisteri	0	0	0	0	0	0.00
Aulodrilus pluriseta	0	0	0	0	0	0.00
Sparganophilia						
Sparganophilus eiseni	0	0	0	0	0	0.00
Polychaeta						
Sabellidae						
Manayunkia speciosa	0	0	0	0	0	0.00
Arthropoda						
Ephemeroptera						
Tricorythidae						
Trichorythodes sp.	0	0	0	0	0	0.00
Caenidae						
Caenis sp.	0	0	0	0	0	0.00
Hexageniidae						
Hexagenia limbata	0	20	40	20	20	1.94

Table B-2 continued

TAXON	Station52 1	2	3	Station Mean	Standard Deviation	Relative Abundance
Trichoptera						
Polycentropodidae						
Phylocentopus sp.	152	0	0	51	88	4.90
Diptera						
Empididae						
Chelifera sp.	0	0	0	0	0	0.00
Cerratopogonidae	0	0	0	0	0	0.00
Chironomidae						
Procladius sp.	152	0	0	51	88	4.90
Apsectrotanypus sp.	0	0	0	0	0	0.00
Rheotanytarsus sp.	0	0	0	0	0	0.00
Chironomus sp.	0	0	0	0	0	0.00
Glyptotendipes sp.	0	0	0	0	0	0.00
Micropsectra sp.	0	152	456	203	232	19.61
Pagastiella sp.	0	152	152	101	88	9.81
Eukieferiella sp.	152	0	0	51	88	4.90
Cladopelma sp.	0	0	0	0	0	0.00
Stictochironomus sp.	0	0	0	0	0	0.00
Xenochironomus sp.	0	0	0	0	0	0.00
Cryptochironomus sp.	0	0	0	0	0	0.00
Cladotanytarsus sp.	0	0	0	0	0	0.00
Phaenopsectra sp.	0	0	0	0	0	0.00
Tanytarsus sp.	0	0	0	0	0	0.00
Potthastia sp.	0	0	0	0	0	0.00
Pupae	0	0	0	0	0	0.00
Crustacea						
Decapoda						
Cambaridae						
Orconectes limosus	0	0	0	0	0	0.00
Amphipoda						
Talitridae						
Hyalella sp.	0	0	0	0	0	0.00
Gammaridae						
Gammarus lacustris	152	0	0	51	88	4.90
Isopoda						
Asellidae						
Caecidotea sp.	152	152	152	152	0	14.71
Lirceus sp.	0	0	0	0	0	0.00
Copepoda	0	0	0	0	0	0.00
Harpacticoda						
Tardigrada	0	0	0	0	0	0.00
TOTALS	1216	780	1104	1033		100

Table B-2. continued.

TAXON	Station 87 1	2	3	Station Mean	Standard Deviation	Relative Abundance
Mollusca						
Gastropoda						
Valvatidae						
Valvata sincera	0	0	0	0	0	0.00
Viviparidae						
Campeloma decisum	0	0	0	0	0	0.00
Pelecypoda						
Sphaeridae						
Pisidium sp.	0	0	0	0	0	0.00
Sphaerium sp	0	0	0	0	0	0.00
Sphaerium heringianus	0	0	0	0	0	0.00
Nematoda	0	2133	2880	1671	1495	37.72
Annelida						
Hirudinea						
Erpobdellidae						
Mooreobdella fervida	0	0	0	0	0	0.00
Glossophoniidae						
Helobdella stagnalis	0	0	0	0	0	0.00
Helobdella fusca	0	0	0	0	0	0.00
Alboglossiphonia heteroclita	0	0	0	0	0	0.00
Oligochaeta						
Enchytraeidae	0	0	0	0	0	0.00
Naididae						
Slavina appendiculata	0	0	320	107	185	2.41
Nais variabilis	0	0	640	213	370	4.82
Pristinella osborni	0	0	0	0	0	0.00
Vejdovskyella intermedia	0	0	0	0	0	0.00
Ophidonais serpentina	0	0	0	0	0	0.00
Chaetogaster diaphanous	0	0	0	0	0	0.00
Lumbriculidae						
Stylodrilus heringianus	0	0	0	0	0	0.00
Tubificidae						
immature without hair setae	256	853	640	583	303	13.16
immature with hair setae	0	0	0	0	0	0.00
Spirosperma ferox	0	0	320	107	185	2.41
Potamothrix vejdovskyi	0	0	0	0	0	0.00
Limnodrilus hoffmeisteri	0	0	320	107	185	2.41
Aulodrilus pluriseta	0	0	0	0	0	0.00
Sparganophilia						
Sparganophilus eiseni	0	0	0	0	0	0.00
Polychaeta						
Sabellidae						
Manayunkia speciosa	0	0	0	0	0	0.00
Arthropoda						
Ephemeroptera						
Tricorythidae						
Trichorythodes sp.	0	0	0	0	0	0.00
Caenidae						
Caenis sp.	0	0	0	0	0	0.00
Hexageniidae						
Hexagenia limbata	0	0	0	0	0	0.00

Table B-2 continued

TAXON	Station 87 1	Station 87 2	Station 87 3	Station Mean	Standard Deviation	Relative Abundance
Trichoptera						
Polycentropodidae						
Phylocentopus sp.	0	0	0	0	0	0.00
Diptera						
Empididae						
Chelifera sp.	0	0	0	0	0	0.00
Cerratopogonidae	0	0	0	0	0	0.00
Chironomidae						
Procladius sp.	0	853	0	284	493	6.42
Apsectrotanypus sp.	0	0	0	0	0	0.00
Rheotanytarsus sp.	0	0	0	0	0	0.00
Chironomus sp.	256	0	0	85	148	1.93
Glyptotendipes sp.	512	0	0	171	296	3.85
Micropsectra sp.	0	0	0	0	0	0.00
Pagastiella sp.	0	0	0	0	0	0.00
Eukieferiella sp.	0	0	0	0	0	0.00
Cladopelma sp.	0	0	0	0	0	0.00
Stictochironomus sp.	0	0	0	0	0	0.00
Xenochironomus sp.	0	0	0	0	0	0.00
Cryptochironomus sp.	0	0	0	0	0	0.00
Cladotanytarsus sp.	0	0	0	0	0	0.00
Phaenopsectra sp.	0	0	0	0	0	0.00
Tanytarsus sp.	0	0	0	0	0	0.00
Potthastia sp.	0	0	0	0	0	0.00
Pupae	0	0	0	0	0	0.00
Crustacea						
Decapoda						
Cambaridae						
Orconectes limosus	0	20	0	7	12	0.15
Amphipoda						
Talitridae						
Hyalella sp.	0	0	0	0	0	0.00
Gammaridae						
Gammarus lacustris	0	0	0	0	0	0.00
Isopoda						
Asellidae						
Caecidotea sp.	512	853	320	562	270	12.68
Lirceus sp.	0	1280	0	427	739	9.63
Copepoda	0	0	0	0	0	0.00
Harpacticoda						
Tardigrada	0	0	320	107	185	2.41
TOTALS	1536	5993	5760	4430		100

Table B-2. continued.

TAXON	Station 102			Station Mean	Standard Deviation	Relative Abundance
	1	2	3			
Mollusca						
Gastropoda						
Valvatidae						
Valvata sincera	0	0	20	7	12	0.53
Viviparidae						
Campeloma decisum	0	0	0	0	0	0.00
Pelecypoda						
Sphaeridae						
Pisidium sp.	0	0	20	7	12	0.53
Sphaerium sp	0	0	20	7	12	0.53
Sphaerium heringianus	0	0	80	27	46	2.14
Nematoda	53	220	100	124	86	9.96
Annelida						
Hirudinea						
Erpobdellidae						
Mooreobdella fervida	0	0	0	0	0	0.00
Glossophoniidae						
Helobdella stagnalis	0	0	0	0	0	0.00
Helobdella fusca	0	0	0	0	0	0.00
Alboglossiphonia heteroclita	0	0	0	0	0	0.00
Oligochaeta						
Enchytraeidae	0	0	0	0	0	0.00
Naididae						
Slavina appendiculata	107	40	40	62	38	4.98
Nais variabilis	0	0	20	7	12	0.53
Pristinella osborni	0	0	0	0	0	0.00
Vejdovskyella intermedia	53	0	60	38	33	3.02
Ophidonais serpentina	0	0	0	0	0	0.00
Chaetogaster diaphanous	53	0	0	18	31	1.42
Lumbriculidae						
Stylodrilus heringianus	0	0	0	0	0	0.00
Tubificidae						
immature without hair setae	320	100	120	180	122	14.41
immature with hair setae	0	0	0	0	0	0.00
Spirosperma ferox	0	40	20	20	20	1.60
Potamothrix vejdovskyi	320	80	180	193	121	15.48
Limnodrilus hoffmeisteri	0	0	0	0	0	0.00
Aulodrilus pluriseta	267	40	20	109	137	8.72
Sparganophilia						
Sparganophilus eisenii	0	0	0	0	0	0.00
Polychaeta						
Sabellidae						
Manayunkia speciosa	53	40	0	31	28	2.49
Arthropoda						
Ephemeroptera						
Tricorythidae						
Trichorythodes sp.	0	0	0	0	0	0.00
Caenidae						
Caenis sp.	0	0	0	0	0	0.00
Hexageniidae						
Hexagenia limbata	0	0	0	0	0	0.00

Table B-2 continued

TAXON	Station 102 1	2	3	Station Mean	Standard Deviation	Relative Abundance
Trichoptera						
Polycentropodidae						
Phylocentopus sp.	0	0	0	0	0	0.00
Diptera						
Empididae						
Chelifera sp.	53	0	0	18	31	1.42
Cerratopogonidae	0	0	0	0	0	0.00
Chironomidae						
Procladius sp.	53	120	120	98	38	7.83
Apsectrotanypus sp.	0	0	0	0	0	0.00
Rheotanytarsus sp.	0	0	0	0	0	0.00
Chironomus sp.	53	0	20	24	27	1.96
Glyptotendipes sp.	0	0	0	0	0	0.00
Micropsectra sp.	53	40	20	38	17	3.02
Pagastiella sp.	0	0	0	0	0	0.00
Eukieferiella sp.	107	320	120	182	120	14.59
Cladopelma sp.	0	0	0	0	0	0.00
Stictochironomus sp.	0	0	0	0	0	0.00
Xenochironomus sp.	0	0	0	0	0	0.00
Cryptochironomus sp.	0	0	0	0	0	0.00
Cladotanytarsus sp.	0	0	0	0	0	0.00
Phaenopsectra sp.	0	0	0	0	0	0.00
Tanytarsus sp.	0	0	0	0	0	0.00
Potthastia sp.	0	0	0	0	0	0.00
Pupae	0	0	0	0	0	0.00
Crustacea						
Decapoda						
Cambaridae						
Orconectes limosus	0	0	0	0	0	0.00
Amphipoda						
Talitridae						
Hyalella sp.	0	0	0	0	0	0.00
Gammaridae						
Gammarus lacustris	0	0	0	0	0	0.00
Isopoda						
Asellidae						
Caecidotea sp.	0	0	0	0	0	0.00
Lirceus sp.	0	0	0	0	0	0.00
Copepoda	0	180	0	60	104	4.80
Harpacticoda						
Tardigrada	0	0	0	0	0	0.00
TOTALS	1547	1220	980	1249		100

Table B-2. continued.

TAXON	Station 165			Station Mean	Standard Deviation	Relative Abundance
	1	2	3			
Mollusca						
Gastropoda						
Valvatidae						
Valvata sincera	152	1280	0	477	699	4.63
Viviparidae						
Campeloma decisum	0	0	20	7	12	0.06
Pelecypoda						
Sphaeridae						
Pisidium sp.	152	0	0	51	88	0.49
Sphaerium sp	0	0	0	0	0	0.00
Sphaerium heringianus	0	0	0	0	0	0.00
Nematoda	304	2560	427	1097	1269	10.64
Annelida						
Hirudinea						
Erpobdellidae						
Mooreobdella fervida	0	0	0	0	0	0.00
Glossophoniidae						
Helobdella stagnalis	0	0	0	0	0	0.00
Helobdella fusca	0	0	0	0	0	0.00
Alboglossiphonia heteroclita	0	0	0	0	0	0.00
Oligochaeta						
Enchytraeidae	0	0	0	0	0	0.00
Naididae						
Slavina appendiculata	0	0	0	0	0	0.00
Nais variabilis	0	640	0	213	370	2.07
Pristinella osborni	0	0	0	0	0	0.00
Vejdovskyella intermedia	0	0	0	0	0	0.00
Ophidonais serpentina	0	0	0	0	0	0.00
Chaetogaster diaphanous	0	0	0	0	0	0.00
Lumbriculidae						
Stylodrilus heringianus	0	640	853	498	444	4.83
Tubificidae						
immature without hair setae	0	1920	3413	1778	1711	17.25
immature with hair setae	0	0	0	0	0	0.00
Spirosperma ferox	0	1920	0	640	1109	6.21
Potamothrix vejdovskyi	0	0	0	0	0	0.00
Limnodrilus hoffmeisteri	0	640	0	213	370	2.07
Aulodrilus pluriseta	0	0	0	0	0	0.00
Sparganophilia						
Sparganophilus einseni	0	0	20	7	12	0.06
Polychaeta						
Sabellidae						
Manayunkia speciosa	0	0	0	0	0	0.00
Arthropoda						
Ephemeroptera						
Tricorythidae						
Trichorythodes sp.	0	0	0	0	0	0.00
Caenidae						
Caenis sp.	0	0	0	0	0	0.00
Hexageniidae						
Hexagenia limbata	0	0	0	0	0	0.00

Table B-2 continued.

TAXON	Station 165			Station	Standard	Relative
	1	2	3	Mean	Deviation	Abundance
Trichoptera						
Polycentropodidae						
Phylocentopus sp.	0	0	0	0	0	0.00
Diptera						
Empididae						
Chelifera sp.	0	0	0	0	0	0.00
Cerratopogonidae	0	0	0	0	0	0.00
Chironomidae						
Procladius sp.	152	640	0	264	334	2.56
Apsectrotanypus sp.	0	0	0	0	0	0.00
Rheotanytarsus sp.	0	0	0	0	0	0.00
Chironomus sp.	152	0	0	51	88	0.49
Glyptotendipes sp.	0	0	0	0	0	0.00
Micropsectra sp.	0	0	0	0	0	0.00
Pagastiella sp.	0	0	0	0	0	0.00
Eukieferiella sp.	0	640	0	213	370	2.07
Cladopelma sp.	0	0	0	0	0	0.00
Stictochironomus sp.	0	0	0	0	0	0.00
Xenochironomus sp.	0	0	0	0	0	0.00
Cryptochironomus sp.	0	0	0	0	0	0.00
Cladotanytarsus sp.	0	0	0	0	0	0.00
Phaenopsectra sp.	0	0	0	0	0	0.00
Tanytarsus sp.	0	0	0	0	0	0.00
Potthastia sp.	0	0	0	0	0	0.00
Pupae	0	0	0	0	0	0.00
Crustacea						
Decapoda						
Cambaridae						
Orconectes limosus	0	0	20	7	12	0.06
Amphipoda						
Talitridae						
Hyalella sp.	0	0	0	0	0	0.00
Gammaridae						
Gammarus lacustris	0	0	0	0	0	0.00
Isopoda						
Asellidae						
Caecidotea sp.	4560	6400	3413	4791	1507	46.49
Lirceus sp.	0	0	0	0	0	0.00
Copepoda	0	0	0	0	0	0.00
Harpacticoda						
Tardigrada	0	0	0	0	0	0.00
TOTALS	5472	17280	8167	10306		100

Table B-2. continued.

TAXON	Station 169 1	2	3	Station Mean	Standard Deviation	Relative Abundance
Mollusca						
Gastropoda						
Valvatidae						
Valvata sincera	0	0	0	0	0	0.00
Viviparidae						
Campeloma decisum	0	0	0	0	0	0.00
Pelecypoda						
Sphaeridae						
Pisidium sp.	0	253	0	84	146	0.87
Sphaerium sp	0	0	0	0	0	0.00
Sphaerium heringianus	0	0	0	0	0	0.00
Nematoda	760	0	0	253	439	2.61
Annelida						
Hirudinea						
Erpobdellidae						
Mooreobdella fervida	0	0	0	0	0	0.00
Glossophoniidae						
Helobdella stagnalis	0	0	0	0	0	0.00
Helobdella fusca	0	0	0	0	0	0.00
Alboglossiphonia heteroclita	0	0	0	0	0	0.00
Oligochaeta						
Enchytraeidae	0	0	0	0	0	0.00
Naididae						
Slavina appendiculata	3230	3040	2533	2934	360	30.22
Nais variabilis	570	253	507	443	168	4.57
Pristinella osborni	0	0	0	0	0	0.00
Vejdovskyella intermedia	1330	1773	760	1288	508	13.26
Ophidonais serpentina	190	0	0	63	110	0.65
Chaetogaster diaphanous	0	0	0	0	0	0.00
Lumbriculidae						
Stylodrilus heringianus	0	0	0	0	0	0.00
Tubificidae						
immature without hair setae	1140	2027	2027	1731	512	17.83
immature with hair setae	0	0	0	0	0	0.00
Spirosperma ferox	1330	507	253	697	563	7.17
Potamothrix vejdovskyi	570	2280	1013	1288	887	13.26
Limnodrilus hoffmeisteri	0	0	0	0	0	0.00
Aulodrilus pluriseta	0	0	0	0	0	0.00
Sparganophilia						
Sparganophilus eiseni	0	0	0	0	0	0.00
Polychaeta						
Sabellidae						
Manayunkia speciosa	0	0	0	0	0	0.00
Arthropoda						
Ephemeroptera						
Tricorythidae						
Trichorythodes sp.	0	0	0	0	0	0.00
Caenidae						
Caenis sp.	0	0	0	0	0	0.00
Hexageniidae						
Hexagenia limbata	0	0	0	0	0	0.00

Table B-2 continued

TAXON	Station 169 1	2	3	Station Mean	Standard Deviation	Relative Abundance
Trichoptera						
Polycentropodidae						
Phylocentopus sp.	0	0	0	0	0	0.00
Diptera						
Empididae						
Chelifera sp.	0	0	0	0	0	0.00
Cerratopogonidae	0	0	0	0	0	0.00
Chironomidae						
Procladius sp.	380	507	0	296	264	3.04
Apsectrotanypus sp.	0	0	0	0	0	0.00
Rheotanytarsus sp.	0	0	0	0	0	0.00
Chironomus sp.	190	507	507	401	183	4.13
Glyptotendipes sp.	0	0	0	0	0	0.00
Micropsectra sp.	0	0	0	0	0	0.00
Pagastiella sp.	0	0	0	0	0	0.00
Eukieferiella sp.	0	0	0	0	0	0.00
Cladopelma sp.	0	0	253	84	146	0.87
Stictochironomus sp.	0	0	0	0	0	0.00
Xenochironomus sp.	0	0	0	0	0	0.00
Cryptochironomus sp.	0	0	0	0	0	0.00
Cladotanytarsus sp.	0	0	0	0	0	0.00
Phaenopsectra sp.	0	0	0	0	0	0.00
Tanytarsus sp.	0	0	0	0	0	0.00
Potthastia sp.	0	0	0	0	0	0.00
Pupae	190	0	253	148	132	1.52
Crustacea						
Decapoda						
Cambaridae						
Orconectes limosus	0	0	0	0	0	0.00
Amphipoda						
Talitridae						
Hyalella sp.	0	0	0	0	0	0.00
Gammaridae						
Gammarus lacustris	0	0	0	0	0	0.00
Isopoda						
Asellidae						
Caecidotea sp.	0	0	0	0	0	0.00
Lirceus sp.	0	0	0	0	0	0.00
Copepoda	0	0	0	0	0	0.00
Harpacticoda						
Tardigrada	0	0	0	0	0	0.00
TOTALS	9880	11147	8107	9711		100

Table B-2. continued.

TAXON	Station 172 1	2	3	Station Mean	Standard Deviation	Relative Abundance
Mollusca						
Gastropoda						
Valvatidae						
Valvata sincera	0	0	0	0	0	0.00
Viviparidae						
Campeloma decisum	0	0	0	0	0	0.00
Pelecypoda						
Sphaeridae						
Pisidium sp.	0	0	0	0	0	0.00
Sphaerium sp	0	0	0	0	0	0.00
Sphaerium heringianus	0	0	0	0	0	0.00
Nematoda	3547	1813	0	1787	1773	12.26
Annelida						
Hirudinea						
Erpobdellidae						
Mooreobdella fervida	0	0	0	0	0	0.00
Glossophoniidae						
Helobdella stagnalis	0	0	0	0	0	0.00
Helobdella fusca	0	0	0	0	0	0.00
Alboglossiphonia heteroclita	0	0	0	0	0	0.00
Oligochaeta						
Enchytraeidae	0	0	0	0	0	0.00
Naididae						
Slavina appendiculata	0	0	0	0	0	0.00
Nais variabilis	253	0	0	84	146	0.58
Pristinella osborni	253	0	0	84	146	0.58
Vejdovskyella intermedia	0	0	0	0	0	0.00
Ophidonais serpentina	0	0	0	0	0	0.00
Chaetogaster diaphanous	0	0	0	0	0	0.00
Lumbriculidae						
Stylodrilus heringianus	0	0	0	0	0	0.00
Tubificidae						
immature without hair setae	11653	22040	2533	12076	9760	82.84
immature with hair setae	0	0	0	0	0	0.00
Spirosperma ferox	0	507	0	169	293	1.16
Potamothrix vejdovskyi	0	0	0	0	0	0.00
Limnodrilus hoffmeisteri	760	120	253	378	338	2.59
Aulodrilus pluriseta	0	0	0	0	0	0.00
Sparganophilia						
Sparganophilus eiseni	0	0	0	0	0	0.00
Polychaeta						
Sabellidae						
Manayunkia speciosa	0	0	0	0	0	0.00
Arthropoda						
Ephemeroptera						
Tricorythidae						
Trichorythodes sp	0	0	0	0	0	0.00
Caenidae						
Caenis sp	0	0	0	0	0	0.00
Hexagenitidae						
Hexagenia limbata	0	0	0	0	0	0.00

Table B-2 continued

TAXON	Station 172 1	2	3	Station Mean	Standard Deviation	Relative Abundance
Trichoptera						
Polycentropodidae						
Phylocentopus sp.	0	0	0	0	0	0.00
Diptera						
Empididae						
Chelifera sp.	0	0	0	0	0	0.00
Cerratopogonidae	0	0	0	0	0	0.00
Chironomidae						
Procladius sp.	0	0	0	0	0	0.00
Apsectrotanypus sp.	0	0	0	0	0	0.00
Rheotanytarsus sp.	0	0	0	0	0	0.00
Chironomus sp.	0	0	0	0	0	0.00
Glyptotendipes sp.	0	0	0	0	0	0.00
Micropsectra sp.	0	0	0	0	0	0.00
Pagastiella sp.	0	0	0	0	0	0.00
Eukiefferiella sp.	0	0	0	0	0	0.00
Cladopelma sp.	0	0	0	0	0	0.00
Stictochironomus sp.	0	0	0	0	0	0.00
Xenochironomus sp.	0	0	0	0	0	0.00
Cryptochironomus sp.	0	0	0	0	0	0.00
Cladotanytarsus sp.	0	0	0	0	0	0.00
Phaenopsectra sp.	0	0	0	0	0	0.00
Tanytarsus sp.	0	0	0	0	0	0.00
Potthastia sp.	0	0	0	0	0	0.00
Pupae	0	0	0	0	0	0.00
Crustacea						
Decapoda						
Cambaridae						
Orconectes limosus	0	0	0	0	0	0.00
Amphipoda						
Talitridae						
Hyalella sp.	0	0	0	0	0	0.00
Gammaridae						
Gammarus lacustris	0	0	0	0	0	0.00
Isopoda						
Asellidae						
Caecidotea sp.	0	0	0	0	0	0.00
Lirceus sp.	0	0	0	0	0	0.00
Copepoda	0	0	0	0	0	0.00
Harpacticoda						
Tardigrada	0	0	0	0	0	0.00
TOTALS	16467	24480	2787	14578		100

Table B-2. continued.

TAXON	Station 183		
	1	2	3
Mollusca			
Gastropoda			
Valvatidae			
Valvata sincera	0	0	0
Viviparidae			
Campeloma decisum	0	0	0
Pelecypoda			
Sphaeridae			
Pisidium sp.	0	0	0
Sphaerium sp	0	0	0
Sphaerium heringianus	0	0	0
Nematoda	0	0	0
Annelida			
Hirudinea			
Erpobdellidae			
Mooreobdella fervida	0	0	0
Glossophoniidae			
Helobdella stagnalis	0	0	0
Helobdella fusca	0	0	0
Alboglossiphonia heteroclita	0	0	0
Oligochaeta			
Enchytraeidae	0	0	0
Naididae			
Slavina appendiculata	0	0	0
Nais variabilis	0	0	0
Pristinella osborni	0	0	0
Vejdovskyella intermedia	0	0	0
Ophidonais serpentina	0	0	0
Chaetogaster diaphanous	0	0	0
Lumbriculidae			
Stylodrilus heringianus	0	0	0
Tubificidae			
immature without hair setae	0	0	0
immature with hair setae	0	0	0
Spirosperma ferox	0	0	0
Potamothrix vejdovskyi	0	0	0
Limnodrilus hoffmeisteri	0	0	0
Aulodrilus pluriseta			
Sparganophilia			
Sparganophilus eiseni	0	0	0
Polychaeta			
Sabellidae			
Manayunkia speciosa	0	0	0
Arthropoda			
Ephemeroptera			
Tricorythidae			
Trichorythodes sp.	0	0	0
Caenidae			
Caenis sp.	0	0	0
Hexageniidae			
Hexagenia limbata	0	0	0

Table B-2 continued

TAXON	Station 183		
	1	2	3
Trichoptera			
Polycentropodidae			
Phylocentopus sp.	0	0	0
Diptera			
Empididae			
Chelifera sp.	0	0	0
Cerratopogonidae	0	0	0
Chironomidae			
Procladius sp.	0	0	0
Apsectrotanypus sp.	0	0	0
Rheotanytarsus sp.	0	0	0
Chironomus sp.	0	0	0
Glyptotendipes sp.	0	0	0
Micropsectra sp.	0	0	0
Pagastiella sp.	0	0	0
Eukieferiella sp.	0	0	0
Cladopelma sp.	0	0	0
Stictochironomus sp.	0	0	0
Xenochironomus sp.	0	0	0
Cryptochironomus sp.	0	0	0
Cladotanytarsus sp.	0	0	0
Phaenopsectra sp.	0	0	0
Tanytarsus sp.	0	0	0
Potthastia sp.	0	0	0
Pupae	0	0	0
Crustacea			
Decapoda			
Cambaridae			
Orconectes limosus	0	0	0
Amphipoda			
Talitridae			
Hyalella sp.	0	0	0
Gammaridae			
Gammarus lacustris	0	0	0
Isopoda			
Asellidae			
Caecidotea sp.	0	0	0
Lirceus sp.	0	0	0
Copepoda	0	0	0
Harpacticoda			
Tardigrada	0	0	0
TOTALS	0	0	0

Table B-3. Benthic invertebrate sorting record.

Sample #	Sub #	Initial ✓	Cr	Mo	In	Ol	Ch	X	Ne		Substrate Notes	Started d/m	Time min.	Fraction	vv	
35-1	1	YR		1		55	28	1	9		-fine plant detritus	5/3	210	1/16	AM	
	2	YR			3	54	26	2	5		-fine grass	5/3	240	1/16	AM	
											- sand					
		/			3	109	54	3	14				450			7.5
35-2	1	AA				2	10	11	1		as above	20/3	30	1/38	AM	
	2	AA				2	5	6				"	30	"	AM	
	3	AA			2	2		6	1			"	30	"	AM	
✓	4	AA	2			3	6	1				"	30	"	—	
	5	AA				2	4	5				"	30	"	—	
		/	2		2	11	25	29	2				150			2.5
35-3	1	AA	1			2	6	5			as above	20/3	45	1/38	AM	
	2	AA	2			2	9	5	1			"	45	"	AM	
✓	3	AA				5	8	4	1			"	45	"	AM	
		/	3			9	23	14	2				135			2.2
52-1	1	AA	1			2					-fine plant detritus	10/3	35	1/38	—	
	2	AA	1			2	2				- bark	"	35	"	AM	
	3	AA	1									"	35	"	AM	
✓	4	AA					1					"	35	"	AM	
	5	AA										"	35	"	—	
		/	3			4	3						175			2.9
52-2	1	AA					1				as above	13/3	35	1/38	AM	
	2	AA										"	35	"	AM	
	3	AA							2			"	35	"	AM	
✓	4	AA	1									"	35	"	AM	
	5	JW					1					"	35	"	AM	
		/	1				2		2				175			2.9

Table B-3. continued.

Sample #	Sub #	Initial ✓	Cr	Mo	In	Ol	Ch	X	Ne		Substrate Notes	Started d/m	Time min.	Fraction	VV	
8233	1	RJ									as above	13/3	35	1/38	—	
	2	RJ										"	35	"	—	
	3	RJ										"	35	"	AM	
✓	4	AA	1				2					"	35	"	AM	
	5	JW				1	3		1			"	35	"	AM	
		/	1			1	5		1				175			2.93
87-1	1	YR	1		1	1	1				- fine plant detritus	16/3	40	1/64	AM	
	2	YR									- aquatic plants	"	40	1/64	AM	
	3	YR				1						"	40	1/64	AM	
	4	YR										"	40	1/64	AM	
	5	YR	2			1	2					"	40	1/64	—	
		/	3		1	3	3						200			3.3
87-2	1	YR				4			2		as above	16/3	45	1/64	AM	
	2	YR	1			3			1			"	45	1/64	AM	
	3	YR	3		1	3			2			"	45	1/64	AM	
✓																
		/	4		1	10			5				135			2.2
87-3	1	YR				5	0	1	4		as above	16/3	60	1/32	AM	
	2	YR				8	1	1	4			"	45	1/32	AM	
✓																
		/				13	1	2	8				105			1.7
102-1		YR				26					- fine plant detritus	4/3	120	1/8	AM	
		JW				25	2			2		"	30	1/8	AM	
		JW				27	6			3		"	30	1/8	AM	
"																
"																
		/				78	8			5			180			3.4

/13

Table B-3. continued.

Sample #	Sub #	Initial √	Cr	Mo	In	Ol	Ch	X	Ne		Substrate Notes	Started d/m	Time min.	Fraction	W	
1652-3	1	JW	13			1	10		6		as above	16/3	45	1/4	AM	
	2	RJ	7			6	6		2			"	30	"	—	
	3	RJ	8			11	10	1	2			"	40	"	AM	
✓	4	RJ	8			10	7	2	1			"	40	"	AM	
			36			28	33	3	11				155			2.5
1652-3	1	RJ				8	36		1		as above	16/3	45	1/4	AM	
	2	RJ				8	24					"	30	"	AM	
✓	3	RJ				8	33		2			"	40	"	AM	
	4	RJ				9	42		2			"	40	"	—	
						33	135		5				155			2.5
1652-3	1	AA	5			3		2			- fine plant detritus	19/3	30	1/32	AM	
	2	AA	9				2	1					40	"	—	
	3	AA	4			3		7					30	"	AM	
✓	4	AA	5					5					40	"	—	
	5	AA	8			1	1	4					30	"	AM	
			31			7	3	9					170			2.:
1652-3	1	YR	3	1	1	25	1		2		as above	19/3	75	1/64	AM	
✓	2	YR	6	2		10	1		2				60	1/64	AM	
✓																
			9	3	1	35	2		4				135			2.:
1652-3	1		5	1		25			1		as above	19/3	60	1/64	AM	
	2		1	1		8							45	1/64	AM	
✓	3		2	2		10							60	1/64	AM	
			8	4		43			1				165			2.

Table B-3. continued.

Sample #	Sub #	Initial √	Cr	Mo	In	Ol	Ch	X	Ne		Substrate Notes	Started d/m	Time min.	Fraction	√√	
169-1	1	JW				16	1		2		-fine plant detritus	17/3	75	1/38		
	2	RJ	1			9	1					"	75	"		
?	3	RJ	1			23	1		2			"	75	"		
✓	4	RJ				21	1	2				"	75	"		
			2			69	4	2	4				300			5.0
169-2	1	AA				23	4				as above	21/3	45	1/38		
	2	AA				23	3	2				"	50	"		
	3	JW				29	2					"	50	"		
						75	9	2					145			2.42
169-3	1	AA				22					as above	21/3	75	1/38		
	2	RJ				33	3					"	60	"		
✓	3	JW				27	2	2				"	60	"		
✓																
						82	5	2					195			3.25
172-1	1	AA				42			3		-fine plant detritus	21/3	60	1/38		
	2	JW				57			3			"	60	"		
	3	JW				42			5			"	60	"		
						141			11				180			3.0
172-2	1	JW				55			1		as above	22/3	45	1/38	AM	
	2	JW				47			2			"	45	"	AM	
✓	3	JW				43			4			"	55	"	AM	
						145			7				145			2.42

Table B-3. continued.

Sample #	Sub #	Initial v	Cr	Mo	In	Oi	Ch	X			Substrate Notes	Started d/m	Time min.	Fraction	W	
172-3	1	RJ				12					as above	22/3	45	1/38	AM	
	2	RJ				16						"	45	"	AM	
	3	RJ				12						"	45	"	AM	
						40							135			2.25
183-1	1	RJ									-sand	23/3	50	1/38	AM	
	2	RJ									-coal fragments	"	50	"	AM	
	3	RJ									- tar specs	"	60	"	—	
													160			2.6
183-2	1	AM									as above	23/3	50	1/38	AA	
	2	AM				1						"	45	"	AA	
	3	AM										"	45	"	—	
						1							140			2.3
183-3	1	AM									as above	23/3	60	1/38	AA	
	2	AM				1						"	45	"	AA	
	3	AM				1						"	45	"	—	
						2							150			2.
												Total	70.17			

APPENDIX C

Sediment Quality Data

Table C-1. Particle size composition of St. Marys River sediments.

All results in percent, dry weight; diameters are in microns (*um*).

Station Number	Sample Date	Sample Time	Water Depth, m	Field Sample Number	Gravel	Sand	Fines	Coarse-Very Fine Sand, <999,>62	Sum of <62,>2.63	Sum of <2.63,>0.17	Coarse Sand, <999,>704	Coarse Sand, <704,>500	Medium Sand, <500,>352	Medium Sand, <352,>250	Fine Sand, <250,>176	Fine Sand, <176,>125
					2000-1000	1000-63	<63									
52	92/08/28	1410	4.5	43487	0.0	34.7	65.3	20.80	67.60	11.60	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	1.8 <T
"	"	1500	4.4	43488	0.0	35.2	64.9	22.60	66.50	10.90	0.0	0.5 <W	1.0 <W	1.0 <W	1.8 <T	3.6 <T
"	"	1525	4.8	43489	0.0	35.4	64.6	21.70	67.80	10.50	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	2.4 <T
35	92/08/28	1210	0.5	43484	0.0	83.2	16.8	80.20	16.00	3.81	0.0	0.5 <W	1.0 <W	1.0 <W	17.4	31.0
"	"	1210	0.5	43485	0.0	73.4	26.6	67.50	26.80	5.68	0.0	0.5 <W	1.0 <W	1.0 <W	7.8	24.1
"	"	1300	0.5	43486	0.0	74.2	25.8	68.50	26.10	5.38	0.0	0.5 <W	1.0 <W	1.0 <W	10.6	23.1
183	92/08/28	1605	2.4	43490	0.0	53.4	46.6	45.90	42.30	11.90	0.0	0.5 <W	1.0 <W	1.4 <T	14.5	13.0
"	"	1640	2.7	43491	0.0	53.9	46.1	46.50	42.00	11.50	0.0	0.5 <W	1.0 <W	1.6 <T	15.0	13.5
"	"	1710	2.6	43492	2.5	72.8	27.6	68.70	24.00	7.66	1.7	4.9	11.9	17.2	15.2	8.6
165	92/08/27	1450	2.8	43481	0.0	28.4	71.6	16.70	68.10	15.20	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	1.1 <T
"	"	1520	2.4	43482	0.0	35.5	64.5	23.90	62.80	13.30	0.0	0.5 <W	1.0 <W	1.0 <W	1.3 <T	4.7 <T
"	"	1540	2.4	43483	0.0	45.4	54.6	35.40	53.00	11.60	2.1	3.1	2.9 <T	2.8 <T	3.4	4.5 <T
172	92/08/27	1308	1.8	43478	0.0	37.7	62.3	25.40	63.10	11.50	0.0	0.5 <W	1.0 <W	1.0 <W	0.8 <T	4.1 <T
"	"	1330	1.5	43479	0.0	38.5	61.5	25.70	63.20	11.10	0.0	0.5 <W	1.0 <W	1.0 <W	0.9 <T	4.1 <T
"	"	1400	1.8	43480	0.0	28.6	71.4	16.10	71.50	12.50	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	1.0 <W
169	92/08/27	1100	7.0	43475	0.0	40.7	59.3	27.10	62.70	10.20	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	3.9 <T
"	"	1135	6.8	43476	0.0	41.5	58.5	27.80	61.70	10.50	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	3.5 <T
"	"	1155	6.9	43477	0.0	43.6	56.4	29.20	61.40	9.41	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	3.2 <T
87	92/08/26	1350	2.2	43472	0.0	38.6	61.4	29.50	56.20	14.30	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	4.9 <T
"	"	1415	2.2	43473	0.0	33.7	66.3	24.20	61.10	14.80	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	1.9 <T
"	"	1435	2.2	43474	0.0	40.0	60.1	30.40	56.30	13.40	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	3.3 <T
102	92/08/26	1020	15.2	43469	0.0	2.2	97.8	0.00	73.30	26.70	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	1.0 <W
"	"	1054	15.3	43470	0.0	5.8	94.2	1.39	74.90	23.70	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	1.0 <W
"	"	1130	15.2	43471	0.0	5.0	95.0	0.72	73.90	25.40	0.0	0.5 <W	1.0 <W	1.0 <W	0.5 <W	1.0 <W

NOTES: "<T" = a measurable trace amount: interpret with caution.
"<W" = no measurable response (zero): less than reported value.

Table C-1. continued.

Station Number	Very Fine Sand, <125,>88	Very Fine Sand, <88,>62	Coarse Silt, <62,>42.2	Coarse Silt, <42.2,>29.8	Medium Silt, <29.8,>21.1	Medium Silt, <21.1,>14.9	Fine Silt, <14.9,>10.5	Fine Silt, <10.5,>7.46	Very Fine Silt, <7.46>5.27	Very Fine Silt, <5.27,>3.73	Coarse Clay, <3.73,>>2.63	Coarse Clay, <2.63,>1.69	Medium Clay, <1.69,>1.01
52	7.2	11.8	14.0	10.9	8.8	7.3	7.0	6.1	5.2	4.6 <T	3.8	3.6	3.0
"	6.9	10.4	12.6	10.3	8.6	7.6	7.4	6.4	5.4	4.6 <T	3.8	3.5	2.8
"	7.7	11.7	13.7	10.6	8.6	7.6	7.4	6.4	5.3	4.5 <T	3.7	3.3	2.7
35	22.9	8.0	3.1	2.3 <T	1.9 <T	1.8 <T	1.8 <T	1.6 <T	1.3 <T	1.2 <T	1.0 <T	1.0 <T	1.0 <T
"	23.8	11.8	5.9	3.9 <T	3.2 <T	2.9 <T	2.9 <T	2.5 <T	2.1 <T	1.8 <T	1.5 <T	1.5 <T	1.4 <T
"	22.6	11.6	5.7	3.8 <T	3.2 <T	2.9 <T	2.9 <T	2.5 <T	2 <T	1.7 <T	1.5 <T	1.5 <T	1.4 <T
183	9.0	8.0	7.6	5.8	5.3	4.7 <T	4.6 <T	4.2 <T	3.7 <T	3.4 <T	3.1	3.2	3.1
"	9.1	7.4	7.4	5.8	5.2	4.8 <T	4.6 <T	4.1 <T	3.7 <T	3.4 <T	3.0	3.2	3.0
"	5.1	4.1	4.0	3.2 <T	3.0 <T	2.7 <T	2.6 <T	2.5 <T	2.2 <T	2.0 <T	1.8 <T	1.9 <T	2.0 <T
165	5.9	9.7	11.6	9.6	8.3	7.5	7.7	7.0	6.1	5.5	4.7	4.6	4.0
"	7.8	10.1	11.6	9.4	8.0	6.9	6.7	6.1	5.3	4.8 <T	4.1	4.0	3.4
"	7.2	9.5	10.0	7.7	6.5	5.7	5.7	5.2	4.6	4.1 <T	3.4	3.3	3.0
172	8.8	11.8	12.3	9.3	8.2	7.3	6.9	6.0	5.1	4.4 <T	3.6	3.4	2.9
"	8.8	12.0	12.8	9.7	8.3	7.2	6.8	5.8	4.9 <T	4.2 <T	3.5	3.3	2.8
"	5.5	10.3	12.5	10.7	9.6	8.6	8.2	7.0	5.8	5.0 <T	4.1	3.8	3.2
169	9.9	13.2	13.6	10.2	8.4	7.2	6.5	5.4	4.4 <T	3.8 <T	3.1	3.0	2.6
"	10.7	13.7	13.7	10.0	8.0	6.7	6.3	5.4	4.5 <T	3.9 <T	3.3	3.1	2.7
"	11.7	14.3	14.3	10.6	8.4	6.8	6.1	4.9 <T	4.0 <T	3.4 <T	2.8	2.8	2.4
87	13.0	11.7	9.1	7.2	6.9	6.6	6.7	6.0	5.2	4.6 <T	3.9	3.9	3.7
"	10.8	11.5	9.5	7.8	7.4	7.2	7.5	6.7	5.7	5.0	4.3	4.3	3.9
"	13.9	13.2	9.6	7.3	6.8	6.6	6.8	6.0	5.1	4.4 <T	3.8	3.8	3.5
102	0.5 <W	0.5 <W	2.2	5.9	8.0	9.7	11.4	10.7	9.5	8.6	7.5	7.7	7.1
"	0.5 <W	1.3 <T	4.5	6.3	8.4	10.1	11.5	10.4	8.9	7.9	6.8	6.9	6.3
"	0.5 <W	0.7 <T	4.2	6.6	8.6	9.9	11.0	10.1	8.7	7.9	6.9	7.2	6.7

Table C-1. continued.

Station Number	Fine Clay, <1.01,>0.66	Fine Clay, <0.66,>0.43	Very Fine Clay, <0.43,>0.34	Very Fine Clay, <0.34,>0.21	Very Fine Clay, <0.21,>0.17
52	1.8	1.3	0.6	0.8	0.6
"	1.6	1.2	0.5	0.8	0.6
"	1.6	1.1	0.5	0.8	0.5
35	0.6 <T	0.5 <T	0.2	0.3	0.2
"	0.9 <T	0.7 <T	0.3	0.5	0.3
"	0.9 <T	0.7 <T	0.3	0.4	0.3
183	2.0	1.5	0.6	0.9	0.6
"	1.9	1.4	0.6	0.8	0.6
"	1.3	1.0 <T	0.4	0.6	0.4
165	2.4	1.7	0.7	1.1	0.7
"	2.1	1.5	0.7	1.0	0.7
"	1.9	1.4	0.6	0.9	0.6
172	1.8	1.3	0.6	0.9	0.6
"	1.7	1.3	0.6	0.8	0.6
"	1.9	1.4	0.6	0.9	0.6
169	1.6	1.2	0.5	0.8	0.5
"	1.7	1.2	0.5	0.8	0.5
"	1.5	1.1	0.5	0.7	0.5
87	2.4	1.7	0.7	1.1	0.7
"	2.4	1.7	0.7	1.1	0.7
"	2.2	1.6	0.7	1.0	0.7
102	4.4	3.1	1.3	1.9	1.3
"	3.9	2.8	1.2	1.7	1.1
"	4.3	3.0	1.3	1.8	1.2

Table C-2. Macro-ion and nutrient concentrations in St. Marys River sediments.

Concentrations/measurement units as noted; all except "field" measurements on dry weight basis.

Station Number	Sample Date	Sample Time	Water Depth, m	Field Sample Number	Field Density g/cm3	Field Redox Potential, mV	Moisture %	Loss on Ignition mg/kg	Organic Carbon, total g/kg		Calcium mg/kg	Chloride mg/kg	Ammonia g/kg	Keldahl Nitrogen, total g/kg	Phosphorus, total g/kg	Solvent Extractables mg/kg
52	92/08/28	1410	4.5	43487	1.244	-41	62	130	56.0		3800	4.40	0.1	2.20	0.40	2672
"	"	1500	4.4	43488	1.252	-44	57	140	69.0		3800	3.80	0.1	2.50	0.39	3027
"	"	1525	4.8	43489	1.240	-215	58	120	54.0		3700	4.30	0.1	2.20	0.35	2445
35	92/08/28	1210	0.5	43484	1.579	-4	24	19.0	14.0		2400	13.0	0.1	0.70	0.32	389
"	"	1210	0.5	43485	1.556	12	34	34.0	16.0		2700	18.0	0.1	1.30	0.48	617
"	"	1300	0.5	43486	1.441	33	40	38.0	16.0		2800	17.0	0.1	1.60	0.51	1085
183	92/08/28	1605	2.4	43490	1.429	-215	32	140	202	RRV	9800	18.0	0.1	1.70	0.31	5695
"	"	1640	2.7	43491	1.447	-245	30	130	214	RRV	11000	19.0	0.1	2.00	0.28	5584
"	"	1710	2.6	43492	1.398	-233	21	110	160	RRV	9100	19.0	0.1	1.60	0.27	4879
165	92/08/27	1450	2.8	43481	1.222	-105	63	110	73.0		4400	17.0	0.1	2.40	0.59	7995
"	"	1520	2.4	43482	1.150	-84	65	120	86.0		4200	17.0	0.1	2.20	0.55	7822
"	"	1540	2.4	43483	1.263	-85	55	86.0	72.0		4000	16.0	0.1	2.20	0.55	7780
172	92/08/27	1308	1.8	43478	1.188	-91	72	100	61.0		4100	27.0	0.1	3.10	0.90	6126
"	"	1330	1.5	43479	1.214	-92	74	110	68.0		3700	23.0	0.2	3.10	0.87	6712
"	"	1400	1.8	43480	1.135	-95	28	110	63.0		3900	31.0	0.2	3.10	0.90	5591
169	92/08/27	1100	7.0	43475	1.231	-120	67	120	71.0		3600	6.40	0.1	2.20	0.69	7112
"	"	1135	6.8	43476	1.222	-125	34	110	73.0		3500	5.80	0.1	2.00	0.61	6855
"	"	1155	6.9	43477	1.199	-124	64	110	82.0		3400	7.70	0.1	1.70	0.59	7385
87	92/08/26	1350	2.2	43472	1.335	-130	50	46.0	23.0		3800	28.0	0.1	1.40	0.47	2233
"	"	1415	2.2	43473	1.350	-110	55	47.0	24.0		3700	18.0	0.1	1.70	0.48	2087
"	"	1435	2.2	43474	1.402	-140	49	38.0	20.0		3800	20.0	0.1	1.30	0.32	--
102	92/08/26	1020	15.2	43469	1.286	-140	63	61.0	38.0		6600	6.40	0.1	2.00	0.78	2850
"	"	1054	15.3	43470	1.271	-130	63	61.0	30.0		6400	5.60	0.1	1.70	0.68	3165
"	"	1130	15.2	43471	1.278	-100	61	59.0	25.0		6500	5.20	0.1	0.93	0.74	2682

NOTES: "RRV" = reported result verified by repeat analysis.

Table C-2. Macro-ion and nutrient concentrations in St. Marys River sediments.

Concentrations/measurement units as noted; all except "field" measurements on dry weight basis.

Station Number	Sample Date	Sample Time	Water Depth, m	Field Sample Number	Field Density g/cm3	Field Redox Potential, mV	Moisture %	Loss on Ignition mg/kg	Organic Carbon, total g/kg		Calcium mg/kg	Chloride mg/kg	Ammonia g/kg	Keldahl Nitrogen, total g/kg	Phosphorus, total g/kg	Solvent Extractables mg/kg
52	92/08/28	1410	4.5	43487	1.244	-41	62	130	56.0		3800	4.40	0.1	2.20	0.40	2672
"	"	1500	4.4	43488	1.252	-44	57	140	69.0		3800	3.80	0.1	2.50	0.39	3027
"	"	1525	4.8	43489	1.240	-215	58	120	54.0		3700	4.30	0.1	2.20	0.35	2445
35	92/08/28	1210	0.5	43484	1.579	-4	24	19.0	14.0		2400	13.0	0.1	0.70	0.32	389
"	"	1210	0.5	43485	1.556	12	34	34.0	16.0		2700	18.0	0.1	1.30	0.48	617
"	"	1300	0.5	43486	1.441	33	40	38.0	16.0		2800	17.0	0.1	1.60	0.51	1085
183	92/08/28	1605	2.4	43490	1.429	-215	32	140	202	RRV	9800	18.0	0.1	1.70	0.31	5695
"	"	1640	2.7	43491	1.447	-245	30	130	214	RRV	11000	19.0	0.1	2.00	0.28	5584
"	"	1710	2.6	43492	1.398	-233	21	110	160	RRV	9100	19.0	0.1	1.60	0.27	4879
165	92/08/27	1450	2.8	43481	1.222	-105	63	110	73.0		4400	17.0	0.1	2.40	0.59	7995
"	"	1520	2.4	43482	1.150	-84	65	120	86.0		4200	17.0	0.1	2.20	0.55	7822
"	"	1540	2.4	43483	1.263	-85	55	86.0	72.0		4000	16.0	0.1	2.20	0.55	7780
172	92/08/27	1308	1.8	43478	1.188	-91	72	100	61.0		4100	27.0	0.1	3.10	0.90	6126
"	"	1330	1.5	43479	1.214	-92	74	110	68.0		3700	23.0	0.2	3.10	0.87	6712
"	"	1400	1.8	43480	1.135	-95	28	110	63.0		3900	31.0	0.2	3.10	0.90	5591
169	92/08/27	1100	7.0	43475	1.231	-120	67	120	71.0		3600	6.40	0.1	2.20	0.69	7112
"	"	1135	6.8	43476	1.222	-125	34	110	73.0		3500	5.80	0.1	2.00	0.61	6855
"	"	1155	6.9	43477	1.199	-124	64	110	82.0		3400	7.70	0.1	1.70	0.59	7385
87	92/08/26	1350	2.2	43472	1.335	-130	50	46.0	23.0		3800	28.0	0.1	1.40	0.47	2233
"	"	1415	2.2	43473	1.350	-110	55	47.0	24.0		3700	18.0	0.1	1.70	0.48	2087
"	"	1435	2.2	43474	1.402	-140	49	38.0	20.0		3800	20.0	0.1	1.30	0.32	--
102	92/08/26	1020	15.2	43469	1.286	-140	63	61.0	38.0		6600	6.40	0.1	2.00	0.78	2850
"	"	1054	15.3	43470	1.271	130	63	61.0	30.0		6400	5.60	0.1	1.70	0.68	3165
"	"	1130	15.2	43471	1.278	-100	61	59.0	25.0		6500	5.20	0.1	0.93	0.74	2682

NOTES: "RRV" = reported result verified by repeat analysis

Table C-3. Inorganics and heavy metals concentrations in St. Marys River sediments.

All concentrations in $mg.kg^{-1}$, dry weight.

Station Number	Sample Date	Sample Time	Water Depth, m	Field Sample Number	Aluminum	Arsenic	Barium	Cyanide	Cadmium	Cobalt	Chromium	Copper	Iron	Lead	Mercury	Magnesium	Manganese	Nickel	Selenium	Silver	Vanadium	Zinc
52	92/08/28	1410	4.5	43487	6100	4.40	30.0	0.010 <W	1.00 <T	3.50	24.0	26.0	7800	18.0	0.03 <T	2200	100	8.80	0.78 <T	0.05 <W	23.0	45.0
"	"	1500	4.4	43488	6200	4.70	31.0	0.010 <W	0.92 <T	3.70	18.0	27.0	8000	18.0	0.04 <T	2200	100	9.30	0.77 <T	0.05 <W	23.0	48.0
"	"	1525	4.8	43489	6000	4.20	29.0	0.010 <W	1.00 <T	3.70	15.0	25.0	7800	17.0	0.04 <T	2200	100	8.60	0.58 <T	0.05 <W	22.0	46.0
35	92/08/28	1210	0.5	43484	2500	6.40	38.0	0.010 <W	0.83 <T	1.20 <T	1900 A	8.80	5900	37.0	0.25	960	81.0	3.90	0.20 <W	0.05 <W	12.0	50.0
"	"	1210	0.5	43485	3100	5.40	52.0	0.010 <W	0.86 <T	2.40 <T	2900 A	11.0	6800	53.0	0.68	1200	100	4.80	0.20 <W	0.05 <W	15.0	78.0
"	"	1300	0.5	43486	3300	7.00	54.0	0.010 <W	0.91 <T	2.50 <T	3000 A	16.0	6900	58.0	0.81	1200	100	4.70	1.00 <T	0.05 <W	15.0	92.0
183	92/08/28	1605	2.4	43490	6100	8.40	43.0	0.430	0.83 <T	6.80	26.0	30.0	21000	28.0	0.04 <T	4000	720	13.0	1.70	0.05 <W	26.0	100
"	"	1640	2.7	43491	6300	9.10	43.0	0.500	0.88 <T	6.20	29.0	30.0	22000	29.0	0.05 <T	4400	820	14.0	2.10	0.05 <W	26.0	110
"	"	1710	2.6	43492	6100	9.10	41.0	0.680	0.70 <T	5.10	29.0	24.0	20000	26.0	0.04 <T	3900	760	12.0	1.80	0.05 <W	26.0	110
165	92/08/27	1450	2.8	43481	8400	17.00	46.0	2.300	0.69 <T	7.40	66.0	60.0	59000	66.0	0.14	4000	610	31.0	1.70	0.05 <T	39.0	200
"	"	1520	2.4	43482	7600	15.00	40.0	1.700	0.68 <T	7.30	87.0	50.0	53000	60.0	0.16	3700	530	28.0	1.40	0.08 <T	34.0	180
"	"	1540	2.4	43483	9300	14.00	45.0	2.200	1.60	8.00	68.0	56.0	53000	60.0	0.16	4000	560	28.0	1.50	0.07 <T	37.0	190
172	92/08/27	1308	1.8	43478	8500	12.00	63.0	0.210	0.54 <T	6.40	93.0	58.0	46000	87.0	0.38	3100	390	23.0	1.50	0.71	33.0	240
"	"	1330	1.5	43479	7000	12.00	58.0	0.014 <T	0.53 <T	6.50	75.0	56.0	42000	86.0	0.44	2800	360	22.0	2.10	0.91	30.0	240
"	"	1400	1.8	43480	7800	12.00	59.0	0.014 <T	0.59 <T	6.10	76.0	59.0	44000	89.0	0.41	3000	370	22.0	1.90	0.79	33.0	250
169	92/08/27	1100	7.0	43475	7400	15.00	42.0	0.410	0.75 <T	6.90	61.0	59.0	53000	75.0	0.22	3300	590	29.0	1.90	0.40	31.0	230
"	"	1135	6.8	43476	6700	14.00	38.0	0.070	0.68 <T	7.40	59.0	58.0	52000	71.0	0.19	3100	560	27.0	1.40	0.34	31.0	220
"	"	1155	6.9	43477	6500	14.00	39.0	0.590	0.53 <T	6.30	53.0	47.0	46000	69.0	0.20	2800	520	25.0	1.40	0.20 <T	29.0	220
87	92/08/26	1350	2.2	43472	7400	5.30	41.0	0.026 <T	0.24 <T	5.80	27.0	24.0	18000	33.0	0.07	3100	240	16.0	0.86 <T	0.10 <T	28.0	110
"	"	1415	2.2	43473	7200	6.30	39.0	0.014 <T	0.34 <T	5.60	26.0	24.0	17000	30.0	0.07	3000	240	15.0	0.81 <T	0.11 <T	27.0	110
"	"	1435	2.2	43474	7300	3.60	38.0	0.310	0.52 <T	5.40	24.0	19.0	15000	28.0	0.07	2800	200	13.0	0.57 <T	0.08 <T	26.0	86
102	92/08/26	1020	15.2	43469	17000	8.80	83.0	0.360	0.58 <T	11.00	49.0	43.0	32000	53.0	0.11	7100	430	30.0	1.40	0.25 <T	51.0	180
"	"	1054	15.3	43470	16000	8.40	80.0	0.300	0.69 <T	11.00	48.0	42.0	32000	55.0	0.10	7000	420	30.0	2.40	0.22 <T	51.0	180
"	"	1130	15.2	43471	15000	6.90	76.0	0.550	0.62 <T	10.00	45.0	40.0	30000	40.0	0.09	6700	380	28.0	1.40	0.24 <T	49.0	150

NOTES: "<T" = a measurable trace amount: interpret with caution.
"A" = approximate result: exceeded normal range limit.

Table C-4. Polycyclic aromatic hydrocarbon concentrations in St. Marys River sediments.

All concentrations in $\mu g.kg^{-1}$, dry weight.

Station Number	Sample Date	Sample Time	Water Depth, m	Field Sample Number	Acenaph-thene	Acenaph-thylene	Anthra-cene	Benzo(a)-anthra-cene	Benzo(b)-fluoran-thene	Benzo(k)-fluoran-thene	Benzo(g,h,i) -perylene	Benzo(a)-pyrene	Chrysene	Dibenzo-(a,h)anthra-cene	Fluoran-thene	Fluo-rene
52	920828	1410	4.5	43487	20 <W	20 <W	20 <W	27 <T	55 <T	43 <T	43 <T	26 <T	49 <T	40 <W	113 <T	221
"	"	1500	4.4	43488	20 <W	20 <W	20 <W	30 <T	58 <T	44 <T	47 <T	30 <T	53 <T	40 <W	124 <T	183 <T
"	"	1525	4.8	43489	20 <W	20 <W	20 <W	32 <T	67 <T	47 <T	54 <T	33 <T	60 <T	40 <W	140 <T	267
35	920828	1210	0.5	43484	20 <W	20 <W	20 <W	34 <T	40 <T	35 <T	40 <W	27 <T	43 <T	40 <W	85 <T	80 <T
"	"	1210	0.5	43485	20 <W	20 <W	20 <W	39 <T	42 <T	37 <T	40 <W	25 <T	48 <T	40 <W	81 <T	99 <T
"	"	1300	0.5	43486	20 <W	20 <W	20 <W	65 <T	73 <T	67 <T	53 <T	32 <T	90 <T	40 <W	172 <T	111 <T
183	920828	1605	2.4	43490	7277	1263	3254	11508	5962	6258	2506	2359	10927	40 <W	68570	9731
"	"	1640	2.7	43491	9204	963	17800	20561	8824	11790	2095	9109	16605	454	106498	15061
"	"	1710	2.6	43492	5532	641	18826	10290	4470	5894	2000	3532	9433	525	55960	9218
165	920827	1450	2.8	43481	176 <T	164 <T	245	1035	1186	891	671	732	1210	177 <T	2538	246
"	"	1520	2.4	43482	147 <T	154 <T	322	1159	1237	957	694	861	1267	207 <T	2742	225
"	"	1540	2.4	43483	135 <T	91 <T	185 <T	723	790	589	468	587	836	131 <T	1575	147 <T
172	920827	1308	1.8	43478	43 <T	120 <T	98 <T	735	967	928	704	576	949	196 <T	1475	59 <T
"	"	1330	1.5	43479	59 <T	141 <T	92 <T	786	1082	950	739	531	1029	209 <T	1607	71 <T
"	"	1400	1.8	43480	72 <T	168 <T	119 <T	967	1305	1093	887	590	1289	240 <T	2131	90 <T
169	920827	1100	7.0	43475	130 <T	117 <T	216	1026	1160	1000	766	989	1137	218 <T	1942	117 <T
"	"	1135	6.8	43476	75 <T	96 <T	145 <T	846	996	866	633	656	981	40 <W	1680	90 <T
"	"	1155	6.9	43477	20 <W	171 <T	230	1880	1626	1564	765	906	1848	40 <W	3382	143 <T
87	920826	1350	2.2	43472	20 <W	20 <W	24 <T	311	427	323	263 <T	380	323	86 <T	395	20 <W
"	"	1415	2.2	43473	20 <W	35 <T	39 <T	258	348 <T	294	263 <T	258	313	73 <T	500 <T	24 <T
"	"	1435	2.2	43474	20 <W	20 <W	20 <W	20 <W	28 <T	24 <T	40 <W	24 <T	21 <T	40 <W	27 <T	20 <W
102	920826	1020	15.2	43469	20 <W	24 <T	45 <T	452	611	493	417	578	452	100 <T	624	23 <T
"	"	1054	15.3	43470	20 <W	20 <W	34 <T	393	609	468	430	576	404	124 <T	500	20 <W
"	"	1130	15.2	43471	20 <W	20 <W	35 <T	320	429	362	282 <T	402	332	84 <T	438	20 <W

NOTES: "<T" = a measurable trace amount: interpret with caution.
"<W" = no measurable response (zero): less than reported value.

Table C-4. continued.

Station Number	Indeno-(1,2,3-cd)-pyrene	Naphtha-lene	Phenan-threne	Pyrene	Total of 16 PAHs
52	42 <T	54 <T	58 <T	64 <T	795
"	47 <T	73 <T	71 <T	72 <T	832
"	51 <T	69 <T	84 <T	80 <T	984
35	40 <W	28 <T	47 <T	68 <T	487
"	40 <W	44 <T	51 <T	66 <T	532
"	56 <T	61 <T	103 <T	145 <T	1028
183	2888	17281	57327	49541	256652
"	2393	10387	90776	68278	390798
"	2195	12642	45944	40587	227689
165	666	3489	1477	1895	16798
"	715	2665	1355	2035	16742
"	471	1397	899	1194	10218
172	727	212	521	1162	9472
"	768	327	608	1246	10245
"	919	365	795	1631	12661
169	785	933	857	1529	12922
"	628	576	731	1329	10328
"	743	1214	1319	2669	18460
87	375 <T	61 <T	145 <T	338	3451
"	275 <T	168 <T	202	409	3459
"	40 <W	46 <T	20 <W	23 <T	193
102	590	139 <T	259	538	5345
"	609	113 <T	202	455	4917
"	422	155 <T	200 <T	375	3836

Table C-5. Chlorinated aliphatics, aromatics and biphenyls in St. Marys River sediment samples.

All concentrations in $ug.kg^{-1}$, dry weight.

Station Number	Sample Date	Sample Time	Water Depth, m	Field Sample Number	Hexachloroethane	Hexachlorobutadiene	2,3,6-Trichlorotoluene	2,4,5-Trichlorotoluene	2,6,a-Trichlorotoluene	1,2,3-Trichlorobenzene	1,2,4-Trichlorobenzene	1,3,5-Trichlorobenzene	1,2,3,4-Tetrachlorobenzene	1,2,3,5-Tetrachlorobenzene	1,2,4,5-Tetrachlorobenzene	Pentachlorobenzene	Hexachlorobenzene	Octachlorostyrene	Total PCBs
52	92/08/28	1410	4.5	43487	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1500	4.4	43488	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1525	4.8	43489	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
35	92/08/28	1210	0.5	43484	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1210	0.5	43485	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1300	0.5	43486	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
183	92/08/28	1605	2.4	43490	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1640	2.7	43491	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1710	2.6	43492	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
165	92/08/27	1450	2.8	43481	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1520	2.4	43482	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1540	2.4	43483	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
172	92/08/27	1308	1.8	43478	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1330	1.5	43479	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1400	1.8	43480	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
169	92/08/27	1100	7.0	43475	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1135	6.8	43476	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1155	6.9	43477	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
87	92/08/26	1350	2.2	43472	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1415	2.2	43473	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1435	2.2	43474	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
102	92/08/26	1020	15.2	43469	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1054	15.3	43470	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W
"	"	1130	15.2	43471	1 <W	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	1 <W	1 <W	1 <W	1 <W	1 <W	1 <W	20 <W

Table C-6. Organochlorine pesticides concentrations in St. Marys River sediments.

All concentrations in ug/kg, dry weight.

Station Number	Sample Date	Sample Time	Water Depth, m	Field Sample Number	Aldrin	alpha-BHC	beta-BHC	gamma-BHC	alpha-Chlordane	gamma-Chlordane	Dieldrin	p,p'-DDD	p,p'-DDE	o,p-DDT	p,p'-DDT	alpha-Endosulfan	beta-Endosulfan	Endosulfan sulphate	Endrin	Heptachlor
52	92/08/28	1410	4.5	43487	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1500	4.4	43488	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1525	4.8	43489	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
35	92/08/28	1210	0.5	43484	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1210	0.5	43485	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1300	0.5	43486	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
183	92/08/28	1605	2.4	43490	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1640	2.7	43491	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1710	2.6	43492	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
165	92/08/27	1450	2.8	43481	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1520	2.4	43482	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1540	2.4	43483	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
172	92/08/27	1308	1.8	43478	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1330	1.5	43479	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1400	1.8	43480	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
169	92/08/27	1100	7.0	43475	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1135	6.8	43476	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1155	6.9	43477	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
87	92/08/26	1350	2.2	43472	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1415	2.2	43473	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1435	2.2	43474	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
102	92/08/26	1020	15.2	43469	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1054	15.3	43470	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W
"	"	1130	15.2	43471	1 <W	1 <W	1 <W	1 <W	2 <W	2 <W	2 <W	5 <W	1 <W	5 <W	5 <W	2 <W	4 <W	4 <W	4 <W	1 <W

NOTES: "<W" = no measurable response (zero): less than reported value.

Table C-6. continued.

Station Number	Hepta-chlor Epoxide	Metho-xychlor	Mirex	Oxy-chlor--dane
52	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
35	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
183	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
165	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
172	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
169	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
87	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
102	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W
"	1 <W	5 <W	5 <W	2 <W

Table C-7. Phenoxy acid herbicide concentrations in St. Marys River sediments.

All concentrations in $\mu g.kg^{-1}$, dry weight.

Station Number	Sample Date	Sample Time	Water Depth, m	Field Sample Number	Dicamba	2,4-D	2,4-DB	2,4-D Propionic Acid	2,4,5-T	Picloram	Silvex
52	92/08/28	1410	4.5	43487	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1500	4.4	43488	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1525	4.8	43489	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
35	92/08/28	1210	0.5	43484	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1210	0.5	43485	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1300	0.5	43486	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
183	92/08/28	1605	2.4	43490	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1640	2.7	43491	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1710	2.6	43492	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
165	92/08/27	1450	2.8	43481	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1520	2.4	43482	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1540	2.4	43483	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
172	92/08/27	1308	1.8	43478	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1330	1.5	43479	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1400	1.8	43480	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
169	92/08/27	1100	7.0	43475	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1135	6.8	43476	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1155	6.9	43477	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
87	92/08/26	1350	2.2	43472	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1415	2.2	43473	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1435	2.2	43474	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
102	92/08/26	1020	15.2	43469	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1054	15.3	43470	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W
"	"	1130	15.2	43471	100 <W	100 <W	200 <W	100 <W	50 <W	100 <W	50 <W

NOTES: "<W" = no measurable response (zero); less than reported value.

Table C-8. Triazine herbicide concentrations in St. Marys River sediments.

All concentrations in $\mu g.kg^{-1}$, dry weight.

Station Number	Sample Date	Sample Time	Water Depth, m	Sample Number	Ametryne	Atrazine	Bladex	Prometone	Prometryne	Propazine	Sencor	Simazine
52	92/08/28	1410	4.5	43487	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1500	4.4	43488	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1525	4.8	43489	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
35	92/08/28	1210	0.5	43484	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1210	0.5	43485	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1300	0.5	43486	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
183	92/08/28	1605	2.4	43490	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1640	2.7	43491	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1710	2.6	43492	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
165	92/08/27	1450	2.8	43481	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1520	2.4	43482	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1540	2.4	43483	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
172	92/08/27	1308	1.8	43478	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1330	1.5	43479	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1400	1.8	43480	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
169	92/08/27	1100	7.0	43475	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1135	6.8	43476	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1155	6.9	43477	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
87	92/08/26	1350	2.2	43472	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1415	2.2	43473	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1435	2.2	43474	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
102	92/08/26	1020	15.2	43469	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1054	15.3	43470	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W
"	"	1130	15.2	43471	50 <W	50 <W	100 <W	50 <W	50 <W	50 <W	100 <W	50 <W

NOTES: "<W" = no measurable response (zero); less than reported value.

Table C-9. Polychlorinated dibenzo-*p*-dioxins and dibenzofurans concentrations in St. Marys River sediments.
All concentrations in $ng.kg^{-1}$, dry weight.

Station Number	Sample Date	Sample Time	Water Depth, m	Field Sample Number	TetraCDD	PentaCDD	HexaCDD	HeptaCDD	OctaCDD	TetraCDF	PentaCDF	HexaCDF	HeptaCDF	OctaCDF
52	92/08/28	1410	4.5	43487	5.3 (2)	3.1 (2)	8 <	16 (2)	41	11 (6)	5.1 (1)	3 <	8 <	20 <
35	92/08/28	1210	0.5	43484	1.9 (1)	4.0 (2)	12 (2)	69 (2)	250	2 <	2 <	3 <	27 (2)	19
183	92/08/28	1605	2.4	43490	2 <	2 <	20 (2)	130 (2)	410	7.9 (2)	6.3 (1)	19 (3)	34 (2)	30
165	92/08/27	1450	2.8	43481	2 <	17 (6)	70 (3)	170 (2)	460	8.0 (1)	14 (1)	20 <	61 (2)	71
172	92/08/27	1308	1.8	43478	19 (4)	22 (6)	49 (2)	120 (2)	360	33 (4)	60 (3)	120 (4)	49 (2)	20 <
169	92/08/27	1100	7.0	43475	5.3 (3)	4.4 (2)	28 (3)	100 (2)	590	34 (8)	5.7 (2)	19 (3)	45 (2)	36
87	92/08/26	1350	2.2	43472	3.9 (3)	2.0 (1)	9 <	54 (2)	170	17 (5)	6.0 (1)	6 <	20 (2)	10 <
102	92/08/26	1020	15.2	43469	6.5 (2)	3.5 (1)	18 (1)	130 (2)	370	34 (7)	12 (1)	10 <	35 (2)	40 <

NOTES: "<" = not detected at concentration indicated.
numbers in parenthese ( ) after concentrations indicate the number of isomers detected in homolog group (OctaCDD and OctaCDF have only one isomer).

Table C-9. continued.

Station Number	2,3,7,8-TetraCDD	1,2,3,7,8-PentaCDD	1,2,3,4,7,8-HexaCDD	1,2,3,6,7,8-HexacDD	1,2,3,7,8-HexaCDD	1,2,3,4,6,7,8-HeptaCDD	2,3,7,8-TetraCDF	1,2,3,7,8-PentaCDF	2,3,4,7,8-PentaCDF	1,2,3,4,7,8-HexaCDF	1,2,3,6,7,8-HexaCDF	2,3,4,6,,7,8-HexaCDF	1,2,3,7,8,9-HexaCDF	1,2,3,4,6,7,8-HeptaCDF	1,2,3,4,7,8,9-HeptaCDF
52	1 <	1 <	8 <	8 <	8 <	8.1	2.1	2 <	2 <	4 <	4 <	5 <	5 <	8 <	8 <
35	1.9	1 <	1 <	2 <	2 <	36	2 <	2 <	2 <	3 <	3 <	3 <	3 <	14	2 <
183	2 <	2 <	3 <	4 <	3 <	61	4.6	4 <	4 <	4 <	4 <	4 <	4 <	13	5 <
165	2 <	4.1	10 <	10 <	10 <	88	8.0	4 <	4 <	10 <	10 <	20 <	20 <	29	10 <
172	3.0	1.9	6 <	6 <	6 <	64	6.2	2 <	2 <	7 <	7 <	7 <	7 <	16	4 <
169	2.3	1 <	3 <	3 <	3 <	53	6.9	1 <	2 <	2 <	2 <	2 <	2 <	15	5 <
87	1.7	1 <	9 <	8 <	9 <	27	3.8	2 <	2 <	6 <	6 <	6 <	6 <	8.0	4 <
102	4.2	3 <	10 <	10 <	10 <	65	7.0	3 <	3 <	10 <	10 <	10 <	10 <	15	9 <

Table C-10. Pearson Product-Moment correlation analysis for selected parameters in St. Marys River sediments (all stations).

	Moist	Fines	TOC	Ca	Cl	TKN	TP	SOLEXT	Al	As	Ba	CN	Cd	Co	Cr	Cu	Fe	Pb	Hg	Mg	Mn	Ni	Se	Ag	V	Zn
Moist	1.00	0.61	-0.06	-0.16	-0.30	0.41	0.57	0.36	0.54	0.18	0.17	0.20	-0.16	0.44	-0.31	0.53	0.38	0.23	-0.09	0.34	0.05	0.53	0.26	0.35	0.52	0.32
Fines	0.61	1.00	-0.04	0.30	-0.40	0.25	0.56	0.35	0.92	0.09	0.50	0.14	-0.27	0.77	-0.53	0.58	0.45	0.11	-0.38	0.77	0.27	0.70	0.44	0.35	0.87	0.37
TOC	-0.06	-0.04	1.00	0.61	0.03	0.55	-0.16	0.79	0.16	0.49	-0.25	0.40	0.23	0.36	-0.53	0.53	0.45	-0.03	-0.37	0.40	0.68	0.36	0.64	0.07	0.26	0.26
Ca	-0.16	0.30	0.61	1.00	0.02	0.07	-0.23	0.41	0.49	0.11	0.28	0.31	0.01	0.56	-0.52	0.24	0.26	-0.24	-0.53	0.74	0.65	0.32	0.61	-0.11	0.48	0.14
Cl	-0.30	-0.40	0.03	0.02	1.00	0.09	0.01	0.04	-0.24	0.20	0.16	0.12	-0.31	-0.08	0.25	-0.06	0.16	0.33	0.37	-0.15	0.22	-0.05	0.07	0.21	-0.16	0.28
TKN	0.41	0.25	0.55	0.07	0.09	1.00	0.42	0.70	0.29	0.44	0.00	0.12	0.08	0.35	-0.37	0.69	0.46	0.30	0.07	0.22	0.30	0.43	0.56	0.50	0.35	0.41
TP	0.57	0.56	-0.16	-0.23	0.01	0.42	1.00	0.33	0.51	0.54	0.65	0.05	-0.28	0.51	0.10	0.67	0.62	0.80	0.42	0.30	0.23	0.63	0.41	0.81	0.58	0.76
SOLEXT	0.36	0.35	0.79	0.41	0.04	0.70	0.33	1.00	0.54	0.72	0.02	0.55	-0.01	0.73	-0.60	0.90	0.84	0.35	-0.29	0.63	0.81	0.80	0.84	0.41	0.66	0.68
Al	0.54	0.92	0.16	0.49	-0.24	0.29	0.51	0.54	1.00	0.26	0.54	0.35	-0.23	0.92	-0.62	0.69	0.63	0.18	-0.45	0.93	0.54	0.84	0.64	0.36	0.97	0.54
As	0.18	0.09	0.49	0.11	0.20	0.44	0.54	0.72	0.26	1.00	0.26	0.60	0.01	0.50	0.04	0.76	0.86	0.79	0.20	0.36	0.75	0.69	0.66	0.48	0.46	0.85
Ba	0.17	0.50	-0.25	0.28	0.16	0.00	0.65	0.02	0.54	0.26	1.00	0.07	-0.21	0.50	0.24	0.29	0.37	0.56	0.35	0.48	0.29	0.40	0.39	0.49	0.54	0.55
CN	0.20	0.14	0.40	0.31	0.12	0.12	0.05	0.55	0.35	0.60	0.07	1.00	0.28	0.48	-0.15	0.46	0.59	0.25	-0.24	0.48	0.62	0.54	0.41	-0.18	0.48	0.42
Cd	-0.16	-0.27	0.23	0.01	-0.31	0.08	-0.28	-0.01	-0.23	0.01	-0.21	0.28	1.00	-0.25	0.19	-0.08	-0.21	-0.18	0.05	-0.18	-0.14	-0.26	-0.09	-0.39	-0.23	-0.31
Co	0.44	0.77	0.36	0.56	-0.08	0.35	0.51	0.73	0.92	0.50	0.50	0.48	-0.25	1.00	-0.58	0.81	0.82	0.35	-0.36	0.95	0.79	0.93	0.79	0.41	0.97	0.73
Cr	-0.31	-0.53	-0.53	-0.52	0.25	-0.37	0.10	-0.60	-0.62	0.04	0.24	-0.15	0.19	-0.58	1.00	-0.47	-0.32	0.39	0.83	-0.64	-0.40	-0.50	-0.46	-0.06	-0.56	-0.07
Cu	0.53	0.58	0.53	0.24	-0.06	0.69	0.67	0.90	0.69	0.76	0.29	0.46	-0.08	0.81	-0.47	1.00	0.91	0.57	-0.13	0.66	0.71	0.92	0.81	0.64	0.80	0.82
Fe	0.38	0.45	0.45	0.26	0.16	0.46	0.62	0.84	0.63	0.86	0.37	0.59	-0.21	0.82	-0.32	0.91	1.00	0.70	-0.07	0.67	0.86	0.94	0.77	0.60	0.78	0.94
Pb	0.23	0.11	-0.03	-0.24	0.33	0.30	0.80	0.35	0.18	0.79	0.56	0.25	-0.18	0.35	0.39	0.57	0.70	1.00	0.62	0.12	0.42	0.53	0.40	0.70	0.34	0.87
Hg	-0.09	-0.38	-0.37	-0.53	0.37	0.07	0.42	-0.29	-0.45	0.20	0.35	-0.24	0.05	-0.36	0.83	-0.13	-0.07	0.62	1.00	-0.54	-0.27	-0.27	-0.17	0.35	-0.38	0.22
Mg	0.34	0.77	0.40	0.74	-0.15	0.22	0.30	0.63	0.93	0.36	0.48	0.48	-0.18	0.95	-0.64	0.66	0.67	0.12	-0.54	1.00	0.76	0.82	0.75	0.22	0.93	0.54
Mn	0.05	0.27	0.68	0.65	0.22	0.30	0.23	0.81	0.54	0.75	0.29	0.62	-0.14	0.79	-0.40	0.71	0.86	0.42	-0.27	0.76	1.00	0.78	0.83	0.31	0.68	0.76
Ni	0.53	0.70	0.36	0.32	-0.05	0.43	0.63	0.80	0.84	0.69	0.40	0.54	-0.26	0.93	-0.50	0.92	0.94	0.53	-0.27	0.82	0.78	1.00	0.76	0.54	0.93	0.84
Se	0.26	0.44	0.64	0.61	0.07	0.56	0.41	0.84	0.64	0.66	0.39	0.41	-0.09	0.79	-0.46	0.81	0.77	0.40	-0.17	0.75	0.83	0.76	1.00	0.47	0.73	0.72
Ag	0.35	0.35	0.07	-0.11	0.21	0.50	0.81	0.41	0.36	0.48	0.49	-0.18	-0.39	0.41	-0.06	0.64	0.60	0.70	0.35	0.22	0.31	0.54	0.47	1.00	0.42	0.72
V	0.52	0.87	0.26	0.48	-0.16	0.35	0.58	0.66	0.97	0.46	0.54	0.48	-0.23	0.97	-0.56	0.80	0.78	0.34	-0.38	0.93	0.68	0.93	0.73	0.42	1.00	0.68
Zn	0.32	0.37	0.26	0.14	0.28	0.41	0.76	0.68	0.54	0.85	0.55	0.42	-0.31	0.73	-0.07	0.82	0.94	0.87	0.22	0.54	0.76	0.84	0.72	0.72	0.68	1.00
TPAHs	-0.28	-0.10	0.54	0.77	0.31	0.25	-0.16	0.63	0.17	0.55	0.06	0.43	0.01	0.42	-0.32	0.39	0.49	0.11	-0.25	0.49	0.83	0.36	0.68	0.05	0.28	0.40
Acny	-0.44	-0.27	0.78	0.75	0.32	0.12	-0.41	0.41	-0.06	0.27	-0.08	0.25	0.11	0.18	-0.25	0.11	0.19	-0.12	-0.25	0.28	0.61	0.05	0.45	-0.13	0.01	0.10
Anth	-0.53	-0.33	0.66	0.76	0.27	-0.01	-0.55	0.26	-0.08	0.12	-0.11	0.21	0.10	0.08	-0.24	-0.06	0.04	-0.27	-0.31	0.26	0.51	-0.06	0.36	-0.26	-0.04	-0.03
BaA	-0.41	-0.23	0.80	0.78	0.29	0.12	-0.36	0.47	0.02	0.35	-0.04	0.31	0.07	0.26	-0.28	0.18	0.28	-0.07	-0.27	0.36	0.70	0.15	0.54	-0.10	0.10	0.20
BbF	-0.32	-0.13	0.83	0.77	0.31	0.22	-0.20	0.59	0.12	0.49	0.05	0.36	0.01	0.38	-0.30	0.33	0.44	0.08	-0.24	0.45	0.80	0.30	0.65	0.05	0.23	0.36
BkF	-0.37	-0.18	0.81	0.78	0.30	0.17	-0.28	0.52	0.06	0.41	0.01	0.30	0.02	0.30	-0.29	0.25	0.35	0.00	-0.25	0.40	0.74	0.21	0.59	-0.01	0.15	0.27
BghiP	-0.26	-0.08	0.84	0.75	0.33	0.29	-0.08	0.65	0.18	0.56	0.11	0.36	-0.04	0.44	-0.31	0.43	0.52	0.17	-0.20	0.48	0.84	0.38	0.71	0.17	0.30	0.45
BaP	-0.32	-0.11	0.80	0.80	0.19	0.18	-0.32	0.51	0.13	0.36	-0.02	0.33	0.08	0.32	-0.35	0.24	0.31	-0.08	-0.34	0.45	0.71	0.23	0.58	-0.08	0.19	0.21
Chry	-0.40	-0.22	0.82	0.77	0.31	0.16	-0.32	0.51	0.03	0.40	-0.02	0.33	0.06	0.28	-0.28	0.22	0.32	-0.02	-0.25	0.37	0.72	0.18	0.57	-0.05	0.12	0.24
DahA	-0.12	-0.01	0.54	0.56	0.40	0.32	0.04	0.48	0.24	0.46	0.24	0.37	-0.07	0.34	-0.22	0.36	0.45	0.20	-0.10	0.43	0.63	0.35	0.61	0.25	0.32	0.42
Flan	-0.43	-0.26	0.81	0.78	0.31	0.13	-0.38	0.47	-0.00	0.35	-0.06	0.32	0.09	0.23	-0.27	0.17	0.27	-0.08	-0.27	0.34	0.69	0.13	0.52	-0.11	0.08	0.18
Fluor	-0.54	-0.34	0.70	0.78	0.22	-0.01	-0.61	0.23	-0.13	0.05	-0.15	0.17	0.19	0.03	-0.24	-0.10	-0.04	-0.35	-0.32	0.21	0.45	-0.14	0.32	-0.33	-0.11	-0.13
IP	-0.25	-0.01	0.81	0.80	0.31	0.26	-0.08	0.63	0.24	0.52	0.17	0.35	-0.06	0.48	-0.34	0.42	0.51	0.15	-0.24	0.54	0.84	0.40	0.72	0.16	0.34	0.44
Naph	-0.38	-0.27	0.80	0.72	0.28	0.10	-0.43	0.49	-0.02	0.38	-0.14	0.52	0.18	0.22	-0.25	0.16	0.28	-0.11	-0.32	0.33	0.68	0.14	0.47	-0.26	0.09	0.14
Phen	-0.48	-0.29	0.77	0.79	0.28	0.06	-0.49	0.37	-0.05	0.23	-0.09	0.28	0.14	0.16	-0.26	0.05	0.15	-0.19	-0.30	0.30	0.60	0.02	0.44	-0.22	0.01	0.05
Pyr	-0.44	-0.26	0.80	0.78	0.30	0.11	-0.39	0.46	-0.01	0.33	-0.06	0.31	0.09	0.23	-0.27	0.15	0.25	-0.10	-0.27	0.34	0.68	0.11	0.51	-0.13	0.07	0.16

NOTE: Underlined correlation coefficients are significant at $p < 0.05$ ($n = 24$).

Table C-10 continued.

	TPAHs	Acny	Anth	BaA	BbF	BkF	BghiP	BaP	Chry	DahA	Flan	Fluor	IP	Naph	Phen	Pyr
Moist	-0.28	-0.44	-0.53	-0.41	-0.32	-0.37	-0.26	-0.32	-0.40	-0.12	-0.43	-0.54	-0.25	-0.38	-0.48	-0.44
Fines	-0.10	-0.27	-0.33	-0.23	-0.13	-0.18	-0.08	-0.11	-0.22	-0.01	-0.26	-0.34	-0.01	-0.27	-0.29	-0.26
TOC	0.84	0.78	0.66	0.80	0.83	0.81	0.84	0.80	0.82	0.54	0.81	0.70	0.81	0.80	0.77	0.80
Ca	0.77	0.75	0.76	0.78	0.77	0.78	0.75	0.80	0.77	0.56	0.78	0.78	0.80	0.72	0.79	0.78
Cl	0.31	0.32	0.27	0.29	0.31	0.30	0.33	0.19	0.31	0.40	0.31	0.22	0.31	0.28	0.28	0.30
TKN	0.25	0.12	-0.01	0.12	0.22	0.17	0.29	0.18	0.16	0.32	0.13	-0.01	0.26	0.10	0.06	0.11
TP	-0.16	-0.41	-0.55	-0.36	-0.20	-0.28	-0.08	-0.32	-0.32	0.04	-0.38	-0.61	-0.08	-0.43	-0.49	-0.39
SOLEXT	0.63	0.41	0.26	0.47	0.59	0.52	0.65	0.51	0.51	0.48	0.47	0.23	0.63	0.49	0.37	0.46
Al	0.17	-0.06	-0.08	0.02	0.12	0.06	0.18	0.13	0.03	0.24	-0.00	-0.13	0.24	-0.02	-0.05	-0.01
As	0.55	0.27	0.12	0.35	0.49	0.41	0.56	0.36	0.40	0.46	0.35	0.05	0.52	0.38	0.23	0.33
Ba	0.06	-0.08	-0.11	-0.04	0.05	0.01	0.11	-0.02	-0.02	0.24	-0.06	-0.15	0.17	-0.14	-0.09	-0.06
CN	0.43	0.25	0.21	0.31	0.36	0.30	0.36	0.33	0.33	0.37	0.32	0.17	0.35	0.52	0.28	0.31
Cd	0.01	0.11	0.10	0.07	0.01	0.02	-0.04	0.08	0.06	-0.07	0.09	0.19	-0.06	0.18	0.14	0.09
Co	0.42	0.18	0.08	0.26	0.38	0.30	0.44	0.32	0.28	0.34	0.23	0.03	0.48	0.22	0.16	0.23
Cr	-0.32	-0.25	-0.24	-0.28	-0.30	-0.29	-0.31	-0.35	-0.28	-0.22	-0.27	-0.24	-0.34	-0.25	-0.26	-0.27
Cu	0.39	0.11	-0.06	0.18	0.33	0.25	0.43	0.24	0.22	0.36	0.17	-0.10	0.42	0.16	0.05	0.15
Fe	0.49	0.19	0.04	0.28	0.44	0.35	0.52	0.31	0.32	0.45	0.27	-0.04	0.51	0.28	0.15	0.25
Pb	0.11	-0.12	-0.27	-0.07	0.08	0.00	0.17	-0.08	-0.02	0.20	-0.08	-0.35	0.15	-0.11	-0.19	-0.10
Hg	-0.25	-0.25	-0.31	-0.27	-0.24	-0.25	-0.20	-0.34	-0.25	-0.10	-0.27	-0.32	-0.24	-0.32	-0.30	-0.27
Mg	0.49	0.28	0.26	0.36	0.45	0.40	0.48	0.45	0.37	0.43	0.34	0.21	0.54	0.33	0.30	0.34
Mn	0.83	0.61	0.51	0.70	0.80	0.74	0.84	0.71	0.72	0.63	0.69	0.45	0.84	0.68	0.60	0.68
Ni	0.36	0.05	-0.06	0.15	0.30	0.21	0.38	0.23	0.18	0.35	0.13	-0.14	0.40	0.14	0.02	0.11
Se	0.68	0.45	0.36	0.54	0.65	0.59	0.71	0.58	0.57	0.61	0.52	0.32	0.72	0.47	0.44	0.51
Ag	0.05	-0.13	-0.26	-0.10	0.05	-0.01	0.17	-0.08	-0.05	0.25	-0.11	-0.33	0.16	-0.26	-0.22	-0.13
V	0.28	0.01	-0.04	0.10	0.23	0.15	0.30	0.19	0.12	0.32	0.08	-0.11	0.34	0.09	0.01	0.07
Zn	0.40	0.10	-0.03	0.20	0.36	0.27	0.45	0.21	0.24	0.42	0.18	-0.13	0.44	0.14	0.05	0.16
TPAHs	1.00	0.92	0.84	0.97	0.99	0.98	0.99	0.93	0.98	0.70	0.96	0.83	0.98	0.92	0.92	0.96
Acny	0.92	1.00	0.85	0.96	0.94	0.95	0.91	0.88	0.97	0.49	0.97	0.94	0.91	0.93	0.97	0.98
Anth	0.84	0.85	1.00	0.92	0.85	0.90	0.79	0.92	0.91	0.70	0.92	0.95	0.79	0.85	0.94	0.93
BaA	0.97	0.96	0.92	1.00	0.98	0.99	0.94	0.96	1.00	0.64	1.00	0.94	0.94	0.94	0.98	1.00
BbF	0.99	0.94	0.85	0.98	1.00	0.99	0.98	0.95	0.99	0.67	0.98	0.86	0.98	0.91	0.94	0.97
BkF	0.98	0.95	0.90	0.99	0.99	1.00	0.96	0.96	1.00	0.67	0.99	0.91	0.96	0.91	0.97	0.99
BghiP	0.99	0.91	0.79	0.94	0.98	0.96	1.00	0.89	0.96	0.67	0.94	0.80	0.99	0.89	0.89	0.94
BaP	0.93	0.88	0.92	0.96	0.95	0.96	0.89	1.00	0.95	0.73	0.94	0.89	0.89	0.86	0.93	0.94
Chry	0.98	0.97	0.91	1.00	0.99	1.00	0.96	0.95	1.00	0.65	1.00	0.92	0.95	0.94	0.98	1.00
DahA	0.70	0.49	0.70	0.64	0.67	0.67	0.67	0.73	0.65	1.00	0.63	0.53	0.67	0.56	0.59	0.62
Flan	0.96	0.97	0.92	1.00	0.98	0.99	0.94	0.94	1.00	0.63	1.00	0.94	0.94	0.95	0.99	1.00
Fluor	0.83	0.94	0.95	0.94	0.86	0.91	0.80	0.89	0.92	0.53	0.94	1.00	0.80	0.89	0.98	0.95
IP	0.98	0.91	0.79	0.94	0.98	0.96	0.99	0.89	0.95	0.67	0.94	0.80	1.00	0.87	0.89	0.93
Naph	0.92	0.93	0.85	0.94	0.91	0.91	0.89	0.86	0.94	0.56	0.95	0.89	0.87	1.00	0.95	0.95
Phen	0.92	0.97	0.94	0.98	0.94	0.97	0.89	0.93	0.98	0.59	0.99	0.98	0.89	0.95	1.00	0.99
Pyr	0.96	0.98	0.93	1.00	0.97	0.99	0.94	0.94	1.00	0.62	1.00	0.95	0.93	0.95	0.99	1.00

Table C-11. Pearson Product-Moment correlation analysis for selected parameters in St. Marys River sediments (only Stations 165, 172, 169 & 87).

	Moist	Fines	TOC	Ca	Cl	TKN	TP	SOLEXT	Al	As	Ba	CN	Cd	Co	Cr	Cu	Fe	Pb	Hg	Mg	Mn	Ni	Se	Ag	V	Zn	TPAHs
Moist	1.00	0.15	0.06	0.23	-0.17	0.06	0.25	0.11	0.24	0.13	0.29	0.42	0.07	0.24	0.19	0.13	0.12	0.12	0.09	0.25	0.15	0.25	0.25	0.11	0.21	0.15	0.11
Fines	0.15	1.00	-0.45	0.98	-0.50	-0.32	0.31	-0.43	0.98	-0.20	0.85	0.37	0.28	0.90	-0.03	0.01	-0.09	-0.16	-0.35	0.96	0.10	0.50	0.28	-0.17	0.95	-0.04	-0.20
TOC	0.06	-0.45	1.00	-0.47	-0.06	0.70	0.57	0.99	-0.44	0.95	-0.17	-0.01	0.47	-0.15	0.82	0.86	0.91	0.91	0.78	-0.40	0.76	0.48	0.60	0.68	-0.21	0.90	0.90
Ca	0.23	0.98	-0.47	1.00	-0.48	-0.35	0.29	-0.43	1.00	-0.24	0.87	0.41	0.28	0.90	-0.02	-0.01	-0.10	-0.17	-0.36	0.97	0.08	0.49	0.26	-0.17	0.95	-0.07	-0.25
Cl	-0.17	-0.50	-0.06	-0.48	1.00	0.42	-0.07	-0.09	-0.51	-0.25	-0.20	-0.67	-0.63	-0.74	-0.03	-0.24	-0.31	-0.02	0.41	-0.65	-0.64	-0.72	-0.29	0.35	-0.59	-0.16	-0.15
TKN	0.06	-0.32	0.70	-0.35	0.42	1.00	0.62	0.67	-0.31	0.66	0.10	-0.47	0.20	-0.23	0.75	0.66	0.60	0.80	0.87	-0.39	0.32	0.17	0.53	0.84	-0.19	0.72	0.61
TP	0.25	0.31	0.57	0.29	-0.07	0.62	1.00	0.58	0.31	0.72	0.65	-0.02	0.45	0.42	0.89	0.87	0.76	0.81	0.71	0.27	0.61	0.71	0.82	0.80	0.49	0.86	0.72
SOLEXT	0.11	-0.43	0.99	-0.43	-0.09	0.67	0.58	1.00	-0.40	0.93	-0.13	0.04	0.53	-0.11	0.84	0.87	0.93	0.92	0.79	-0.35	0.77	0.51	0.63	0.70	-0.17	0.90	0.87
Al	0.24	0.98	-0.44	1.00	-0.51	-0.31	0.31	-0.40	1.00	-0.19	0.87	0.43	0.31	0.92	0.01	0.03	-0.06	-0.13	-0.35	0.98	0.13	0.53	0.30	-0.17	0.96	-0.03	-0.21
As	0.13	-0.20	0.95	-0.24	-0.25	0.66	0.72	0.93	-0.19	1.00	0.03	0.06	0.56	0.11	0.86	0.94	0.96	0.92	0.69	-0.14	0.89	0.69	0.73	0.65	0.05	0.95	0.96
Ba	0.29	0.85	-0.17	0.87	-0.20	0.10	0.65	-0.13	0.87	0.03	1.00	0.17	0.34	0.78	0.38	0.31	0.17	0.21	0.13	0.80	0.16	0.55	0.54	0.32	0.89	0.27	0.02
CN	0.42	0.37	-0.01	0.41	-0.67	-0.47	-0.02	0.04	0.43	0.06	0.17	1.00	0.46	0.46	0.01	0.07	0.17	-0.04	-0.31	0.49	0.39	0.46	0.08	-0.33	0.43	0.04	0.01
Cd	0.07	0.28	0.47	0.28	-0.63	0.20	0.45	0.53	0.31	0.56	0.34	0.46	1.00	0.53	0.58	0.67	0.69	0.56	0.27	0.37	0.74	0.75	0.65	0.34	0.47	0.60	0.36
Co	0.24	0.90	-0.15	0.90	-0.74	-0.23	0.42	-0.11	0.92	0.11	0.78	0.46	0.53	1.00	0.19	0.28	0.23	0.09	-0.25	0.96	0.45	0.77	0.49	-0.08	0.97	0.21	0.05
Cr	0.19	-0.03	0.82	-0.02	-0.03	0.75	0.89	0.84	0.01	0.86	0.38	0.01	0.58	0.19	1.00	0.96	0.92	0.97	0.86	-0.01	0.71	0.65	0.79	0.88	0.22	0.96	0.80
Cu	0.13	0.01	0.86	-0.01	-0.24	0.66	0.87	0.87	0.03	0.94	0.31	0.07	0.67	0.28	0.96	1.00	0.98	0.96	0.75	0.06	0.86	0.78	0.83	0.77	0.27	0.99	0.87
Fe	0.12	-0.09	0.91	-0.10	-0.31	0.60	0.76	0.93	-0.06	0.96	0.17	0.17	0.69	0.23	0.92	0.98	1.00	0.94	0.70	-0.01	0.91	0.77	0.78	0.68	0.19	0.97	0.89
Pb	0.12	-0.16	0.91	-0.17	-0.02	0.80	0.81	0.92	-0.13	0.92	0.21	-0.04	0.56	0.09	0.97	0.96	0.94	1.00	0.87	-0.14	0.75	0.62	0.80	0.85	0.09	0.98	0.87
Hg	0.09	-0.35	0.78	-0.36	0.41	0.87	0.71	0.79	-0.35	0.69	0.13	-0.31	0.27	-0.25	0.86	0.75	0.70	0.87	1.00	-0.42	0.35	0.22	0.58	0.97	-0.18	0.79	0.67
Mg	0.25	0.96	-0.40	0.97	-0.65	-0.39	0.27	-0.35	0.98	-0.14	0.80	0.49	0.37	0.96	-0.01	0.06	-0.01	-0.14	-0.42	1.00	0.23	0.61	0.32	-0.24	0.96	-0.02	-0.16
Mn	0.15	0.10	0.76	0.08	-0.64	0.32	0.61	0.77	0.13	0.89	0.16	0.39	0.74	0.45	0.71	0.86	0.91	0.75	0.35	0.23	1.00	0.90	0.71	0.35	0.36	0.83	0.81
Ni	0.25	0.50	0.48	0.49	-0.72	0.17	0.71	0.51	0.53	0.69	0.55	0.46	0.75	0.77	0.65	0.78	0.77	0.62	0.22	0.61	0.90	1.00	0.79	0.30	0.72	0.73	0.63
Se	0.25	0.28	0.60	0.26	-0.29	0.53	0.82	0.63	0.30	0.73	0.54	0.08	0.65	0.49	0.79	0.83	0.78	0.80	0.58	0.32	0.71	0.79	1.00	0.66	0.49	0.84	0.69
Ag	0.11	-0.17	0.68	-0.17	0.35	0.84	0.80	0.70	-0.17	0.65	0.32	-0.33	0.34	-0.08	0.88	0.77	0.68	0.85	0.97	-0.24	0.35	0.30	0.66	1.00	-0.00	0.78	0.60
V	0.21	0.95	-0.21	0.95	-0.59	-0.19	0.49	-0.17	0.96	0.05	0.89	0.43	0.47	0.97	0.22	0.27	0.19	0.09	-0.18	0.96	0.36	0.72	0.49	-0.00	1.00	0.21	0.03
Zn	0.15	-0.04	0.90	-0.07	-0.16	0.72	0.86	0.90	-0.03	0.95	0.27	0.04	0.60	0.21	0.96	0.99	0.97	0.98	0.79	-0.02	0.83	0.73	0.84	0.78	0.21	1.00	0.91
TPAHs	0.11	-0.20	0.90	-0.25	-0.15	0.61	0.72	0.87	-0.21	0.96	0.02	0.01	0.36	0.05	0.80	0.87	0.89	0.87	0.67	-0.16	0.81	0.63	0.69	0.60	0.03	0.91	1.00

NOTE: Underlined correlation coefficients are significant at $p < 0.05$ ($n = 12$).